10/1/35
Univ. of Michigan Library
Ex Edc

THE JOURNAL OF ENGINEERING EDUCATION

Published by the Society for the Promotion of Engineering Education

Published under the supervision of the Publication Committee.
R. I. Rees, Dexter S. Kimball, F. L. Bishop, Editor, University of Pittsburgh.
Published at Lancaster, Pa.

Entered as second-class matter at the Post Office at Lancaster, Pa., under the Act of March 3, 1870.

New Series
Vol. XX, No. 1. SEPTEMBER, 1929 Subscription Price, $3.00 per year. Single Copies, 50 cents

TABLE OF CONTENTS

IRVING PORTER CHURCH Awarded the Lamme Medal 1
Irving Porter Church 2
Cooperation. R. I. Rees, President 3
Address of Welcome. George W. Rightmire 6
Response. Dexter S. Kimball 9
The Economic and Social Significance of Engineering. Presidential Address. Dexter S. Kimball 10
Report of the Board of Investigation and Coordination. Charles F. Scott, Chairman 23
The 1930 Sessions of the Summer School for Engineering Teachers. H. P. Hammond, Director 24
Report of the Secretary, 1928–29. F. L. Bishop 26
The 1929 Session of the Summer School for Engineering Teachers .. 37
Personnel of the School 42
Report of Committee on Resolutions 43
James Watt. Ira N. Hollis 46
The Industrial Revolution. Joseph W. Roe 78
A Resume of Mechanical Engineering Since James Watt, William D. Ennis 89
Minutes of the Council Meetings 115
Minutes of the Regular Sessions of the Society 122

Officers, 1929–30 131
Council 132
Board of Investigation and Coordination 133
Committees for 1929–30 134
Divisions of the Society 136
Proceedings of the Society 137
New Members 138
Obituary:
Horace William Marsh 139
Edward Robinson 140
College Notes 142
Sections and Branches 144
Book Review 146

ENGINEERING DEPT. LIBRARY

HEADQUARTERS OF THE SOCIETY

UNIVERSITY OF PITTSBURGH, PITTSBURGH, PA.

OFFICERS OF THE SOCIETY, 1928–29

President

DEXTER S. KIMBALL, Cornell University, Ithaca, N. Y.

Vice-Presidents

C. C. WILLIAMS, University of Iowa, Iowa City, Iowa
G. M. BRAUNE, University of North Carolina, Chapel Hill, N. C.

Secretary

F. L. BISHOP, University of Pittsburgh, Pittsburgh, Pa.

Treasurer

W. O. WILEY, Jno. Wiley & Sons, New York City

Assistant Secretary

NELL MCKENRY, University of Pittsburgh, Pittsburgh, Pa.

BOARD OF INVESTIGATION AND COORDINATION

BISHOP, F. L., *Secretary*, University of Pittsburgh, Pittsburgh, Pa.
JACKSON, D. C., Massachusetts Institute of Technology, Cambridge, Mass.
KIMBALL, D. S., Cornell University, Ithaca, N. Y.
SACKETT, R. L., Pennsylvania State College, State College, Pa.
SCOTT, CHAS. F., *Chairman*, Yale University, New Haven, Conn.
TURNEAURE, F. E., University of Wisconsin, Madison, Wis.

WICKENDEN, W. E., Director of Investigations, 33 West 39th Street, New York City.
HAMMOND, H. P., Associate Director, 33 West 39th Street, New York City.
SPAHR, R. H., Member of Staff, 33 West 39th Street, New York City.

278552

IRVING PORTER CHURCH

Recipient, Second Lamme Medal, Society for the Promotion of Engineering Education, June 21, 1929.

IRVING PORTER CHURCH AWARDED THE LAMME MEDAL

We take pleasure in announcing that Irving Porter Church, Emeritus Professor of Applied Mechanics and Hydraulics at Cornell University, was awarded the second Lamme Medal by the Society for the Promotion of Engineering Education on June 21, 1929, at its thirty-seventh annual meeting, The Ohio State University, Columbus Ohio.

This medal is awarded annually by this Society for "accomplishment in technical teaching or actual advancement in the art of technical training," funds for the purpose having been provided by the will of the late Benjamin G. Lamme, formerly Chief Engineer of the Westinghouse E. & M. Company.

Professor Church was born in Ansonia, Conn., July 22, 1851. He graduated with the degree of C.E. in 1873, and in 1878 received his M.C.S. from Cornell University. He entered private practice, but in 1874–76 was Assistant Master, Ury House School; 1876–92 was Assistant Professor of Civil Engineering, 1892–93 Associate Professor, 1893–1916 Professor of Applied Mechanics and Hydraulics, and Professor Emeritus since 1916, Cornell University.

His influence as a teacher has been very extensive, but he is more widely known as the author of clear and logical textbooks on Mechanics, Hydraulics and other subjects.

278552

IRVING PORTER CHURCH

BY E. WILLIS WHITED

Former Student of Professor Church

When the Lamme Medal was presented to Professor Irving P. Church of Cornell University, his former students were particularly happy to know that the sterling qualities they knew so well had been recognized by the leading educators of the country. We had always considered ourselves especially fortunate to have had the privilege of sitting in his classes and listening to his magnificent expositions of his own complicated and intricate subject, applied mechanics. Professor Church and his mechanics are inseparable and to all his students, the mention of either one brings to mind the other.

Professor Church was first of all a teacher. A student, from the time he entered the university as a freshman, felt his influence in every class room. He wanted his students to think independently and to use their imaginations. He welcomed new interpretations and new demonstrations from any student and was always glad to discuss and explain fully every question which any one of us might raise. Inasmuch as he was an outstanding pioneer in applied mechanics, these opportunities came very frequently.

He taught us to search out the basic elements of an engineering problem and to apply sound methods in arriving at a solution. His former students feel that much of what skill they may have in attacking new problems was learned in his class room.

When the word went out that he had retired from active work in the class room, we were very sorry that Cornell students had lost the opportunity to feel the impress of his personality. "Poppy" Church, as he is lovingly called, has stamped his ideals and habits of thought on the minds of every one of us who were fortunate enough to sit in his classes. He may well be called one of the greatest of the teachers of mechanics.

CO-OPERATION

R. I. REES

President of the Society

One of the significant developments since the World War has been a clear realization of interdependence between industry and engineering education. Modern industry has been built on the firm foundation of science and its engineering applications. In steadily increasing measure the work of the world demands men with minds trained through engineering discipline: not only for the technology of business but even more, perhaps to exercise this discipline in positions of executive responsibility. In spite of the growth of their laboratories for applied research, industries small and large look ever more hopefully to the engineering school laboratories for revelation as to how to make more secure what they have and how to develop new economic fields of conquest.

Contact between engineering colleges and industry is a mutual blessing. On the one hand, intimate knowledge by the teacher of the actual problems and processes of the industries makes each of them an authoritative counsellor of the undergraduate in his choice of an occupation; it gives him an understanding of the types of graduates needed and the fundamental training most essential. The unsolved problems of industry become known to him and indicate significant fields for his engineering research. In general, can such co-operation and mutual understanding do otherwise than develop, broaden and enrich engineering education?

Industry, on the other hand, is indebted to engineering education beyond all realization. Out of campus laboratories have come discoveries which form the basis for many of our most prosperous industries. Beyond all this, however, is the contribution of trained human talent without which business could never have reached its present high standard of productiveness and efficiency. But the field in which industry to-

day most needs help is in the education and training on the job of its own personnel. It owes to each man it employs the opportunity for him to develop to his highest ability and capacity. This alone spells success. Industrial management takes over the responsibility of the college faculty and supervision becomes almost synonymous with teaching. Is it not clear in this co-operative endeavor that engineering education has much to contribute in procedure—in incentive, standards, and methods—toward this continuing process of education?

Splendid undertakings in co-operation are already under way in many, if not all, of the engineering colleges of the country. The most successful efforts are, undoubtedly, those in which the special industries of the local community are given first consideration. This has started in a number of instances through the organization of committees representing the several industrial interests. It has made possible an interchange of expert opinion and a combined consideration between faculty and industrial representatives of problems of mutual concern. Engineering colleges generally draw the majority of their students from certain clearly defined areas, although some are of national character. The obligations to these areas, together with certain responsibilities to state and nation, would roughly indicate the spread of service and the interest in industrial activities. It is doubtless true that each college has detailed information concerning the business and industrial activities in the communities which they most intimately serve but it is thought that a general view of industrial distribution will be of interest.

The following table gives this. It is compiled from authoritative sources and shows how widespread throughout the United States engineering activity is and also how extremely numerous in almost every section of the country are the industries that formal engineering has not yet reached. It, therefore, gives a graphic picture of the extent of the new industrial fields still to be conquered by one form or another of technical education.

A picture of this kind makes us realize that, in the last analysis, co-operation between education and industry is the

DISTRIBUTION OF INDUSTRIAL ACTIVITIES (Census of Manu

EAST			CE	
New England Maine New Hampshire Vermont Massachusetts Rhode Island Connecticut	**Middle Atlantic** New York New Jersey Pennsylvania	**South Atlantic** Delaware Maryland District of Columbia Virginia West Virginia North Carolina South Carolina Georgia Florida	**East North** Ohio Indiana Illinois Michigan Wisconsin	**East South** Kentucky Tennessee Alabama Mississippi
				Population (1920 Census)—105,7
7,400,909	22,261,144	13,990,272	21,475,543	8,893,307
				Engineering Enrollment 1925–1926
6,371	12,436	5,690	13,293	2,493
				Number of Industrial Establishment
17,745	62,276	17,029	43,671	7,637
				Number of Wage Earners—8,35
1,098,748	2,467,791	879,060	2,309,860	359,542
				Value of Product (Millions of Dolla
6,028	19,533	4,632	18,988	1,808
				Horse Power—39,045,940
4,566,155	10,968,754	3,980,297	11,101,846	1,787,386
				Major Types of Industrial Activ
Cotton and woolen goods Silk manufacturing Dyeing Boots and shoes Leather goods Lumber and timber products Paper and pulp Electrical machinery Textile machinery Ship and boat building Marble, granite and slate Brass and bronze Non-ferrous alloys Hardware Jewelry Office supplies Typewriters	Men and women's clothing Boots and shoes Iron and steel Coke Foundry and machine shops Electrical machinery Motor vehicles Smelting and refining Petroleum refining Chemicals Paints and varnishes Dyeing and finishing Silk manufacturing Printing and publishing Household furnishings Ship building Food products Glass	Textiles and knit goods Clothing Lumber and timber products Furniture Pulp Boat and ship building Tobacco products Iron and steel Coke Foundry and machine shops Railway equipment Meat packing Leather Food products Bread and bakery products Printing and publishing Turpentines and rosin Pottery	Motor vehicles Electrical machinery Engines and turbines Iron and steel Foundry and machine shops Agricultural implements Rubber goods Slaughtering and meat packing Food products Lumber and timber products Furniture Paper Boots and shoes Knit goods Brass and bronze Non-ferrous alloys Clay products	Iron and steel Foundry and machine shops Stoves and ranges Cotton goods Knit goods Boots and shoes Slaughtering and meat packing Tobacco products Lumber and timber products Turpentine and rosin Cotton seed oil Clay products

Note.—The above data include manufacturing and fabricating industries. They do not include banking, p

us of Manufactures—Department of Commerce) 1927

	CENTRAL		WEST	
UTH ky ee a ppi	WEST NORTH Minnesota Iowa Missouri North Dakota South Dakota Nebraska Kansas	WEST SOUTH Arkansas Louisiana Oklahoma Texas	MOUNTAIN Montana Idaho Wyoming Colorado New Mexico Arizona Utah Nevada	PACIFIC Washington Oregon California
BUS)—105,710,620				
07	12,544,249	10,242,224	3,336,101	5,566,871
1925–1926—59,315				
93	7,279	4,326	3,605	3,822
ABLISHMENTS—191,866				
17	16,192	8,208	3,919	15,189
NERS—8,353,977				
12	448,192	267,142	94,957	428,685
OF DOLLARS)—67,720				
08	4,733	2,399	981	3,614
39,045,940				
56	2,033,074	1,419,558	829,256	2,350,614
TRIAL ACTIVITIES				
hine shops neat packing r products sin	Slaughtering and meat packing Flour and grain products Food products Lumber and timber products Printing and publishing Petroleum refining Foundry and machine shops Engines and turbines Electrical machinery Boots and shoes Clothing Clay products	Lumber and timber products Ship building Petroleum refining Sugar refining Smelting and refining Foundry and machine shops Food products Slaughtering and meat packing Printing and publishing	Lumber and timber products Petroleum refining Smelting and refining Foundry and machine shops Printing and publishing Food products Canning and preserving Sugar Wall coverings Floor composition	Lumber and timber products Paper Furniture Ship and boat building Motion pictures Printing and publishing Oil and petroleum refining Food products Foundry and machine shops Electrical machinery Household appliances

e banking, public utilities, agriculture, mining and other extractive industries such as oil.

combined effort of all to determine exactly what the work of the world really is and to find out how all the young manhood of the land can best be trained to do with excellence the special work that each one is best fitted to do. Engineering education in America has had an outstanding history. But it still has ahead, before this goal is reached, equally extraordinary opportunities.

Summary of Distribution of Engineering Students for the United States

One student to each 1,780 of population.

One student to each 3.2 of industrial establishments.

One student to each 140 industrial wage earners.

One student to each $1,140,000 of annual industrial production.

One student to each 660 industrial horse power.

ADDRESS OF WELCOME

GEORGE W. RIGHTMIRE

Ohio State University, Columbus, O.

You come here at an auspicious time. This building, in which we are now seated, is just being completed. Much equipment remains to be brought in. The experiment station, in which you are all interested, is taking long strides forward. We have been able to staff it a little better for next year than ever before. It is filling a place in the lives of the people of Ohio. We even have a branch in the southeast section of the State which we operate in cooperation with the State of Ohio. So, the engineering experiment station will be an object of some interest to you. This Chemistry Building, which is a magnificent new building, will also be an object of some interest.

Further than that, the Legislature of Ohio, during this past winter, has seen fit to deal more generously, more appreciably with the University than ever before. Some concrete evidences of that appreciation on the part of the State Legislature, which will appeal to you certainly, are rather handsome appropriations for new equipment, better equipment, in the laboratory of my dear friend here, Professor Magruder, and also in the laboratory of my other friend, Professor Caldwell, also in the laboratories of another friend, Professor John Younger.

In Physics, and so on, the Legislature has handsomely enabled us to go around in places where, as you doubtless have experienced in your institutions, the tendency is for laboratory equipment to become obsolescent in time and in some cases obsolete, but still you have to go on using it. We hope to repair such situations wherever they exist here.

We are glad, also, that we have a college of Engineering in this institution. The College of Engineering has at least two influences: One, naturally, is educational, and the other is a general influence throughout the University. A University

has many colleges, some of which may be called cultural in which the student is never called upon to get dirty during the entire college course. Those colleges have a good object lesson before them in the lives of these students and professors in engineering who labor even to the middle of the night in these laboratories and drawing rooms and who put on overalls and run an engine test or tear to pieces a dynamo. They are not afraid of dirt and sweat and old clothes. I think that is a good example to hold up before the College of Education and Liberal Arts and the College of Commerce, with great groups of students among whom the white collar idea prevails principally, not only here but after they get out.

The College of Engineering and the College of Agriculture, in these land-grant institutions, have had a wholesome influence on the lives of the students in the other colleges in the University and also on the aims and procedures of the University.

I think, today, were it not for the presence of the Agricultural Colleges and the Engineering Colleges in these great state universities there would be a good deal more of the theoretical than there is there today. The engineer does not get on without being practical. I think that is a fine influence which the College of Engineering extends over a campus such as ours, giving an air of practicality, hard work, no fear of the dirt, getting down to the elemental things in every-day life.

We appreciate also the fine activity of this Society for the Promotion of Engineering Education in the last few years. It has shown a deal of hardihood and courage and tenacity of purpose in taking up the study of its own courses and curricula. Many of our professors have been interested in the work of the Board of Investigation and Coordination. One of our graduates has been very influential in that Committee since the beginning. Others of them here, and elsewhere, have been vitally interested in the thought that is being expressed there and the results that are gradually being worked out.

In 1926 your Board came on with a partial report of progress and some conclusions. Those conclusions as they

were drawn at that time, I think, looked very hopeful. Three years have elapsed since that time and we would be very happy, in being your hosts at this annual meeting, if at this meeting there might be some finality which this committee is ready to give to the organization of its study of the general subject of engineering education. We are vitally interested in that. We should be happy, indeed, if this might be the place where your committee would finally reach conclusions about what the undergraduate in the College of Engineering ought to be, and what he ought to do, and what he ought to study.

I am assuming now, a little bit, from the program, that you have gotten through studying the undergraduate engineering students. This program, on the face of it, seems to be marked "The Graduate and His Work." We are going now into the next field and we are all gratified to give any assistance we may in that field.

On behalf of the College of Engineering here, the members of which have already given you a most cordial welcome to the campus, on behalf of the University, our entire University community, I give you the greetings of the institution and express to you the hope that this meeting may be very fruitful, very productive and in the judgment of our visitors may constitute one of the best meetings ever held.

All the facilities of the University, which you can make use of, are at your disposal. I hope you will feel perfectly at home here. I think Professor Magruder and Dean Hitchcock have already handed you the keys of the campus. I hope you will use them freely and will feel that we are glad to see you. We will express that in every way we can. We hope your meeting will be a most happy and beneficial one.

RESPONSE TO ADDRESS OF WELCOME

DEXTER S. KIMBALL

President of the Society

Dr. Rightmire, in thanking you for these kind words of welcome I wish to say that this Society has profited greatly by such kindnesses as yours in inviting us to meet at institutions of this kind. It is one of the best things that could have happened to us. We do not know enough about each other, we do not know enough about sister institutions and you are right that institutions should know more about each other and engineering should know more about the other parts of the University.

Some years ago there was a convention in Ithaca at which were present some diggers of Greek roots, ethnologists and Latin-Greek scholars. A little reception was given by Dr. Sherman for the group. Each visitor had detailed to him a member of the faculty to see that he was escorted into the dinner. It fell to my lot to take in a very elderly man from one of the old institutions who was one of these men well-steeped in ancient Classics and writings. As we walked along he said, "What study are you interested in?"

I said, "Engineering."

"Oh, yes, a very useful study and from what I hear a very interesting study."

But, it was as far away from his as Mars. I fear that is true of most Universities today. We do not know enough about each other. I am sure great profit comes to us from meeting in institutions of this kind. I thank you, sir, for your kindly words and I am sure we will carry away many happy memories of this meeting.

THE ECONOMIC AND SOCIAL SIGNIFICANCE OF ENGINEERING *

BY DEXTER S. KIMBALL

President of the Society for the Promotion of Engineering Education; Dean, College of Engineering, Cornell University, Ithaca, N. Y.

At one time we, in Cornell University, put out a questionnaire to the students in an endeavor to ascertain the reason for their choice of Cornell as the place to study. The answers were many and varied, but there was one that has always stood out in the minds of everyone because it was so heartfelt and sincere, and it was, "God only knows!"

That is the answer you would get when asking any economist or philosopher as to what the end of this industrial civilization may be. There are, however, certain outstanding accomplishments, such as we might call over-all dimensions, that are significant and to which I would like to call your attention.

The most ancient and the most insistent cry that has gone up from the human heart has been a prayer to be relieved of hard and unremitting toil; to enjoy some of the good things of earth, to be able to rear one's family in comfort, and to have at least some physical, mental and spiritual pleasures before departing this mundane existence. This thought is written on all his monuments from time immemorial and has always colored man's philosophy of life and of the life to come.

Denied, as most men have been, the comforts of life, they have always carried over, in their philosophy and religion, to the other world a hope at least that they might enjoy some of these things over there that were denied them here.

One of the most touching, and one of the most beautiful,

* Presidential address delivered at the thirty-seventh annual meeting of the S. P. E. E., at the Ohio State University, Columbus, Ohio, June 19–22, 1929.

things that has come to us from antiquity you will find in the Metropolitan Museum in New York. It is a little figure of a servant girl carrying a basket of food on her head buried with her master in order that she might come to life on the other side and serve him.

All the philosophies of life are tinctured with this same thought. It is a most amazing thing that people who have been so long on the face of the earth had not given more thought to this problem of making a living. I wonder what would have happened to us if the ancient Greeks had turned the searchlight of their keen minds on the problem of making a living instead of directing it on speculative philosophy. I have no doubt they would have done more for posterity than they have done through philosophy, great as that may be.

It remained for a comparatively small group of humble engineers to change all of this viewpoint. Suddenly out of a clear sky there came the Industrial Revolution, changing all of our ideas of production, opening up a vista of hope and promise hitherto denied to humanity. Just exactly what this means as yet we do not know, but it—the Industrial Revolution—has opened up a hope that had never been thought of or dreamt of up to that time. Truly, as Bertrand Russell has said, if there has been poverty and want since the Industrial Revolution it has been because of ignorance and selfishness. I do not need to tell you the results of the Industrial Revolution. You are aware of them as well as I. It may be sufficient to say that at this present moment, for the first time, we are producing more than we can use. That condition is new in the history of civilization.

The problems before Congress today are not those of finding enough to go around, but finding out, if they can, what to do with the surplus that we have. We grow more food than we can eat, and if we should turn all of our productive machinery to the task of producing the necessities of life we would not know what to do with it all, so changed is the situation. For the first time we are within striking distance of the abolition of poverty and want. We have also gathered enough of the world's goods so that we can supply the necessities for sup-

porting other fields, such as medicine, the most noble of all professions, in such a substantial manner that we may hope to conquer our most dreaded enemy—disease.

A new vista dawns on all humanity. But, no sooner do we get within touching distance of this great accomplishment than we are greeted by a chorus of complaints, criticisms, wagging of heads and lifting of hands to high heaven! We engineers are reminded of this terrible machine civilization, and many insist that we are making the world worse instead of better, and it would be wiser to leave things as they were. The criticisms are loud and many. I do not need to tell you, you who have lived on great campuses, what they are like. All of you have lived through a period when such things as engineering were tolerated on the campus rather than invited. These complaints and criticisms may be divided into two groups:

First, those that are concerned with ethical and religious problems.

Second, those that are concerned with economic and social problems.

This is not the time, nor the place, to discuss the ethical and religious side of the influence of modern industry. However, there are two points that I would like to touch upon.

One of the important, outstanding complaints is that our modern methods are destroying religion and morals and thus the rising generation is all different and truth is likely to suffer.

I cannot get wildly excited over that criticism. Truth is not a delicate baby; she is a sturdy old lady. She has stood a lot of buffeting and she is not easily toppled over. All that we may do, perhaps, is to throw some light on truth and make truth, perhaps, a little clearer. But neither you nor I, nor all the scientists or engineers will ever upset truth. A great deal of nonsense has been said both by scientists and theologians and I cannot get excited as to the ultimate end of truth. She is competent to care for herself.

There is one other phase of the ethical discussion, too, that I would like to speak about briefly. That is the changing view-

point in regard to worldly well-being, the production of wealth. I can remember when we were taught that wealth was a dreadful thing and that the possession of wealth was the surest way to go to the devil entirely. We are now looking on that somewhat differently because it has dawned upon us slowly—and it has not dawned upon everybody—that only through the possession of the good things of this earth can we have some other things that we desire and that all men have desired from time immemorial. Perhaps there never was a time when wealth has been evaluated as carefully as it is at the present moment. And never before has wealth been so freely used for general education and uplift. Never before have the evils of poverty been so fully realized.

We turn now to the other class of criticisms of this industrial age. I can only speak of two or three of those because the list is too long and I wish to say only enough to illustrate my point. The first and most outstanding criticism is the one I have mentioned, that the world is no better than it was, but rather worse, that we engineers have built a Frankenstein that will destroy us and is destroying all the good things of earth.

They tell us that people are not as happy as they used to be, that the possession of all of these fine things, like radios, autos, movies, clothes, foods, and so forth, in abundance is not good for people, that the world is not as good as it used to be. I know many people who really believe that and who say that people are not as happy as they used to be. They point out that all of these new things that we have given them have made them restless, and so forth.

It stands to reason that you cannot take a great people, such as we have here today, and release them as they have been released, to a large extent, from toil, surround them with comfort, as they have never been nor their forebears, and expect to find no changes in manners. Of course things are different, and of course we have released many things that are pretty jazzy, if I may use the word, and there is a great deal of turbulence and noise throughout the world.

I am not so sure, however, about the young folks. You

know as much about them as I do, but I am inclined to think they are just as good now as this generation was that is sitting before me, at their age. You cannot expect to make a reform of any kind without paying the penalty in some way. That, again, is a problem of education and one that we need not be disturbed over. Necessarily, we are going to have some difficulties in bringing about all of these great improvements. Personally, I see nothing to be greatly disturbed over. Some of the new things we have introduced which are most decried —for instance, radio and the phonograph—I suppose are numbered among the greatest educational tools the world has ever known.

Another charge these same people make is that justice is as far away as when Plato described it as the essence of all virtues. They point out that we have not been able to distribute the fruits of our industry equitably, that want and poverty still stalk the land. That is true to some degree.

As far as justice goes, industrial justice, I do not believe there ever was a time when industrial justice stood on such a high level. Those of you who know what is going on in the legal mind know they are making great efforts to rewrite our industrial code, and in this there is great hope for the future. Never before has the public been so sensitive to industrial injustice. Certainly, it will take time to bring about any great change but there never was a time when lawyers or law makers—I might distinguish between the two—were so much concerned with this problem. Again, there is hope in that direction and those who have studied that problem carefully will agree with me, I am sure.

Then we have another group that is much concerned with other influences of this new age. I have in mind a certain group that is much concerned about art. They are quite sure that we are destroying all art. That, of course, is an old idea. It emanated a great many years ago from William Morris in England and still has a large following.

Here, again, you are dealing with something that is going through an evolution. It is not possible to release forces, such as we have released, to change all our ideas of life—or

many of them—and to change our ideas of architecture and methods of living and not change art. After all, art is nothing more than an expression of people's ideas of life. That is too long a story to go into. I only want to hold out one idea for your consideration. No man who has studied modern architecture for instance can fail to be impressed with what architects have done in the last twenty-five years. They have evolved, in many cases, a new type of architecture symbolic of our day and date, just as Greek architecture has visualized their mode of life and has expressed it in beautiful forms. In the same way other forms of art must find a way out, and they will.

Incidentally, I think artists themselves have done more mischief than all the engineers have, but you cannot convince them of that. Some of you might have seen the Independent Artists' Exhibit on the upper floor of the Waldorf last winter. You would have been quite convinced that what I say is true, that hope for art does not lie in artists but in those who are trying to apply it in all forms of life. I am not disturbed about art.

There is one favorite criticism: That the engineers and the scientists with their terrible weapons will destroy all human life. The next war is to be the last war and everybody will be wiped out. I have an idea that the first stone ax came in for the same criticism. They probably said, "Look what that fellow has. He has an ax on that handle; he will surely wipe us all out." May be he could, but in spite of that for centuries the race has made progress. It has increased in numbers, defensive methods all the time keeping pace with offensive methods. I cannot get wildly excited over that criticism. I am inclined to think if we make the progress we have been making in recent years that possibly even in your day we may evolve some ways and means of getting around that difficulty.

I could go on and name many other criticisms that you could answer yourself; that all can be answered and will be answered in the way the engineer and the medical scientist

answer them. Not by saying, what is the use, let's quit. But, What is the solution and what is the cure?

Let us look for a moment at some of the people who make these criticisms. That is an important matter. They are to be found everywhere and on every college campus. The first are those, as I say, who are much disturbed over these changed conditions. You will find among them people who firmly believe that the old ways were the best. They will tell you the old ways were the *natural* ways, that men were brought into the world to do certain things and that you cannot change that at all. Society was foreordained in good old Presbyterian fashion to have a certain form and therefore the natural old way is the proper one. That has been an old idea of humanity. Philosophers have held many different ideas of that sort, and if you go far enough back you will find that philosophers taught that life was not worth living at all. It is amazing the number of magazine articles that you will find tinctured with this idea, that it is not wise to change old ways, that they are all right, and that something is going to happen if you do.

One thing that these people are afraid will happen is something like this: They say it would not be a good thing to have man get too much money because something dreadful would happen to him. They have an idea that certain people are constitutionally so fitted that they can have money and spend it wisely; but it might not do for others to have too much money. They think some people might run amuck if they did have it, they might spend some of it for something foolish. I do not get that viewpoint. I have an idea that all people are capable of development, more or less, and that as we come along in this world, building as we will a higher, a richer, a fuller civilization, that people can be trusted to spend money. They are making it and spending it freely now, and that worries some good people.

To place one of the older persons in the new environment is confusing and in many respects terrifying for them. When anyone listens to a talk such as you heard last night, and is not acquainted with this field of engineering and science, it is a puzzling and a terrifying thing, and it is little wonder they

are afraid that something is going to happen. We are always afraid of the things that we do not understand.

Ignorance is one of the greatest difficulties under which we labor, ignorance of this great civilization, its background, ignorance of what engineers and scientists are doing and fear that something unknown is going to happen. That appears in amusing ways in articles, solemnly written articles, in magazines in regard to automatons. One of these articles appeared a few months ago, solemnly and seriously, to the effect that the writer was afraid that engineers were going to make this world entirely automatic and that all the work would be done by automatic machines and that something terrible was going to happen to all humanity. Now if that man had experience in trying to keep automatic machines in order he would not have written that article. Every engineer knows that that is a fairy tale and that it is foolish. Yet it is written solemnly and we are held up as the monsters that are going to change the face of all creation.

Then there is a group of people whose personal comfort has been disturbed, that is to say, life is different, it is not as easy to live as it was and these personal comforts must come to them through other channels. That cannot be helped, there can be no progress without change. Change does not necessarily mean progress, but there can be no progress without change. All our methods of life will be changed and are being changed and the comforts of life will come in another way than through slavish personal service as in the good old days so much bemoaned. The iceman will not come to deliver ice. We are not doing that now in many cases. All of our comforts are to be given to us in new and different ways. When I look back and think that when I was born we were carrying letters across the continent by horse—in the good old way, the natural way and it was the natural thing to do—I am not surprised that these people are disturbed. The interesting thing is that if you take any of these persons aside and talk to them—and many of them to whom I have spoken have talked to me frankly—they will tell you of these terrible times. I

say, "Let's see, you say you would like to go back to the good old simple days."

They answer, "Yes, life used to be comfortable on the campus then. There were no automobiles, no radios, etc."

"You are quite sure about that?"

"Yes!"

"Then you would be willing to forego the telephone?"

They are not sure about that.

"Would you forego the automobile, the street car, the telephone, pure water, etc., etc.?" And the more you enumerate these things the less sure they are that they want to go back. They do not think of it in that light. They think of the change that has been made in their physical surroundings and they worry largely because of lack of mental adaptability to these new conditions of life.

Over against these changes stand certain accomplishments and certain outlooks that we should keep in mind as engineers and engineering educators. Modern industry took its roots in this country in the Connecticut Valley in the middle of the last century. The first attempts at modern manufacturing, as we understand it, were made in that Valley.

The census of 1850 gives the per capita wealth of this country as $383; the last preliminary census, in fact every census, shows that this has stepped up every year through good years and through bad years, through good times and through bad times, until the per capita wealth of this country has risen to about $4,000. The preliminary estimates of the census last year indicates that we are worth, in this country, over $400,000,000,000 and the national income last year was $90,000,000,000. No people have ever talked about such sums of money; no people have ever possessed such sums of money or anything approaching it; no people have ever made money at such a rapid rate. Nothing like it has ever been known since time began. Not only that, but this wealth is more widely distributed than ever known before.

A German lady was visiting on the campus at Cornell last summer. She was an intelligent woman from among one of the groups visiting the United States, trying to find out the

secret of this great growth of which people abroad hear and because of which they look upon us with fear, wonder and envy. They do not know what it is all about. They do not know and for that reason they fear our competition and with good cause. This lady was taken around the campus in the car of one of the professors. As they got into the car she said, "Do you own this car?"

"Yes." (Later he told me he did not tell her how much he owed upon it.)

"Do all the professors have cars?"

"Oh, yes, some of them have two."

"How many cars are there in the United States?"

He happened to know and told her there were 25,000,000. He said there was one for every five persons and also told her if every man in the United States next Sunday would load his car to capacity, the entire population could go for a ride. And that is true.

She thought for a while and then said, "One car for every five persons?"

"Yes."

"Including women and children?"

Note the social significance of that question. He said, "Yes, including women and children."

In other words, we count women and children as part of those who are to have happiness on earth. That is a new idea in many quarters as yet.

She said, "Ach Himmel! Ach Himmel! This is too much."

You can get the viewpoint of those people from abroad and you can get the viewpoint also, if you will pardon the personal reference, of others and it is a thing that we should weigh carefully in this country.

When I was twenty-two years of age I went to work for the Union Iron Works in San Francisco. They had just laid the keel of the Charleston, one of the very first of the new Navy. That vessel was not a big ship, even for her day; she was 3500 tons and designs were bought from the Armstrongs in England. I do not know whether we did not know enough and were afraid to design such a ship or what. However, the fact

remains that the designs were bought from Armstrong. The Chief Inspector on the ship was Dr. Ira N. Hollis, whom so many of you know so well.

From that short time, 1887, we have assumed naval importance to such a degree that we challenge the command of the sea. If we wish to make fifteen cruisers, as we voted, we can build them, or we can build twenty-five, or forty-five, or fifty-five, or as many as we need. Therefore, you can well understand how these people on the other side wonder what it is all about. It is a thought to sober us. It does give us a position of tremendous power which we should consider very carefully and use wisely.

Referring again to this great wealth that we have created it has, as I said, raised us to a level such as no other nation has ever attained and given us a promise and an outlook hitherto unknown. Already new ideals are beginning to take form in certain practices of ours. We assume, for instance, and it is the first civilization to so assume, that every child shall be educated. We can do it. Just as soon as you raise a man economically, you broaden his vision, you raise his ideals and that is what has happened to us. We assume that every child should have an education because we can give it to him. As we go along we shall have other assumptions and we shall assume other broadening viewpoints and just as we are permitted to do so economically we may raise ourselves to a higher civilization.

I think perhaps more important than any of these material things that have come to us is the idea of progress. The theologians and all the philosophy of the last century taught us, and I was so taught and many of you were so taught, that the age of wisdom lay back of us; that back of us somewhere there was a Utopian time, ancient Greece possibly or some other time when all men were wise and happy, and we should mend our ways and increase our wisdom by studying these old and reliable men who are long since gone; that there could not be anybody as wise as the ancients were. Now we know that in engineering and science that is not so. We are looking forward and not backward. The idea of progress has be-

come firmly embedded in our minds. We expect to go forward and we expect to make progress. Already that viewpoint is taking hold in many fields besides engineering.

Economics, of which I spoke, is being radically revised and will be changed. Here is something that may interest you: Some time before Mr. Hoover was nominated he started an investigation, the result of which has been published under that name of "Recent Economic Changes." He asked a group of economists to study the modern industrial structure since the war. The National Bureau of Economic Research was called upon to direct the study. Funds were provided and they began a study of certain cross sections of this industrial era to see if they could lay out, in order, what had taken place. The committee in charge of this study called into consultation, and to write certain portions of that report, some engineers. Never before, as far as I am aware, have economists or any persons interested in economic studies, called on engineers to help them write such a report. It is the first recognition of the fact that our industrial basis is complex and changing rapidly in a manner best known to engineers.

The next series of textbooks on economics will be different from those that were built on Adam Smith. That, again, is a realization that we are living in a new world.

I have spoken of education aside, altogether, from the assumption that everybody should be educated. I think the greatest change that has come in our system of education is the view that underlies all such institutions as this, where we are guests.

It is not so many years ago when education was conceived as referring to something that had taken place, and true education in many universities is still looked upon as the study of the humanities and the classics. No one will doubt the importance of these fundamental studies in the humanities and in the classics in the history of our race but we, at least institutions such as this—and it is representative of the group before me—believe also that education should be used for all manner of things, that it is not confined to any walk of human life, that it is all-inclusive, that research and study belong to

everything imaginable that affects human welfare. All knowledge is for use and there is nothing common or unclean in education. That is a larger viewpoint and it has changed our educational ideas and the industrial aspect in this country.

You probably all remember the story of the Pied Piper of Hamlin and the interpretation given by the lame boy of his flutings,

> "For he led us he said to a glorious land
> Joining the town and close at hand,
> Where waters gushed and fruit trees grew
> And flowers put forth a fairer hue
> And everything was strange and new.
> The sparrows were brighter than peacocks here
> And their dogs outran our fallow deer
> And honey bees had lost their stings
> And horses were born with eagles' wings."

We scientists, engineers and engineering educators are the Pied Pipers of the modern industrial world. Where we lead all men will follow because only where we walk can there spring up an industrial background, fair and fertile, without which there can be no progress, without which the ancient prayer cannot be answered, and without which Civilization itself is a foolish dream.

May God help us to realize our responsibilities and possibilities!

REPORT OF THE BOARD OF INVESTIGATION AND COORDINATION SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

The report of the investigation of engineering education undertaken by the Society through its Board of Investigation and Coordination is now in the hands of the printer. The findings and the preliminary reports, which have appeared during the progress of the enterprise in the Society's monthly JOURNAL OF ENGINEERING EDUCATION and in sixteen pamphlet reprints, issued as Bulletins or Reports, are now brought together, revised, and supplemented in the complete report. Extended summaries are presented in the contributions by the Board and by the Director.

The report will include the study of technical institutes which has been carried on during the past year and a half by Mr. Robert H. Spahr under the direction of Director Wickenden.

The complete report of over 1,000 pages will be sent to all members of the Society who are not in arrears for dues.

At its inception, a minimum of five years was scheduled for the completion of the project; it is not quite six years since Mr. Wickenden took up his work as Director of Investigations. He resigns from the service of the Society on September first and assumes the presidency of Case School of Applied Science.

Professor H. P. Hammond has been made Director of the Summer School for Engineering Teachers which is under the immediate supervision of the Board. Plans are now being made for the fourth session to be held in 1930 at Yale. This session will be devoted to civil engineering.

CHARLES F. SCOTT,
Chairman.

THE 1930 SESSIONS OF THE SUMMER SCHOOL FOR ENGINEERING TEACHERS

By H. P. HAMMOND

Director of the Summer School

By action of the Board of Investigation and Coordination, and with the ratification of the Council of the Society, the invitation of Yale University to hold a session of the Summer School for Engineering Teachers at that institution during 1930 has been accepted. It will be devoted to methods of teaching civil engineering and will continue for approximately three weeks, beginning just after the Society's annual meeting at Montreal. The session will be sponsored by the American Society of Civil Engineers, through action of its Board of Direction, and will also be conducted with the cooperation of the Portlant Cement Association and possibly one other agency.

Professor J. C. Tracy of the Sheffield Scientific School will serve as the Local Director of the Session. As in the past the staff will be chosen from the leading teachers, practicing engineers and executive leaders of the country. Part of the session, as at present planned, will be held at New Haven, and part at the Yale Surveying Camp, Lyme, Connecticut.

The general plan of the session of 1929, described elsewhere in this issue, will be followed. Part of the program will be of a general nature relating to the common elements of all civil engineering instruction and will be conducted for the entire group of teachers in attendance, and part will be held in divisional meetings relating to the principal divisions of civil engineering curricula: structural engineering, highway and railway engineering, sanitary and hydraulic engineering, and surveying. Portions of the program relating to economic elements of civil engineering practice and civil engineering instruction, to contracts and specifications, to materials of con-

struction, and to professional ethics and professional practices will be common to all of the divisions. As in the past sessions a certain portion of the program will be devoted to educational principles and to methods of teaching in general.

Applications to attend the session will be acted upon in accordance with priority of receipt. Some applications have already been received. Others may be sent to the writer at 99 Livingston Street, Brooklyn, N. Y.

It is also possible that a session of the Summer School will be held in 1930 for teachers of engineering graphics. An invitation to hold such a session at the Carnegie Institute of Technology, Pittsburgh, was accepted by the Society's Council, and by the Board of Investigation and Coordination, contingent upon the possibility of making suitable arrangements and the securing of necessary funds. As soon as it is known definitely whether such a session will be held announcement to that effect will be made in the JOURNAL. Applications to attend the session may be addressed to the writer as stated above.

REPORT OF THE SECRETARY, 1928–29

F. L. BISHOP

The membership of the Society in 1894 was 156; it reached the 200 mark in 1897, the 300 mark in 1904, jumped to 675 in 1908, and in 1911, reached 1,071. It took seventeen years more to reach 2,000, and in April, 1929, when the year book went to press, there were 2,086 individual, and 117 institutional, a total of 2,203 members. With this increasing membership, the interest in the Society has also increased until today the influence of the Society is felt throughout the entire educational world. We frequently receive letters from obscure points of the world asking for further information concerning the Society and its work, and what the qualifications for membership are. The Society has responded to this desire of its members for increased knowledge of engineering education by increasing the size of its publication—THE JOURNAL OF ENGINEERING EDUCATION—to include so far as possible everything of value, by giving as complete information as possible on all questions, and by its representatives on various committees and councils. All this activity involves the expenditure of money which brings us to the topic of

FINANCES

When the Society was organized in 1893, there was an admission fee of $3.00 charged and the dues were $2.00 per year. Later this admission fee was abolished. The dues were raised to $3.00, then $4.00, and last year to $5.00. This Society is one of the few organizations which does not charge a registration fee at its meetings. The expenditure of the money of the Society is handled through the Executive Committee which consists of the president, the secretary, and the treasurer. The treasurer, Mr. W. O. Wiley, has served the Society in this capacity since 1907 and much credit is due him for the excellent manner in which the funds have been handled.

Rigid economy is necessarily practiced. For the past three or four years a small surplus is shown. This would be a little larger and more work could be accomplished if each member would pay his dues when first notified. The past year it was necessary for the Secretary to send out four notices of dues and there is still outstanding over $1,000, about one-half of which will not be collected.

Council

The Council is the governing body of the Society and is composed of twenty-one elective members, the officers, and the past presidents. The Society has had a distinguished group of men as its presidents and there are twenty of the thirty-four still active on the Council. Thus the Council is composed of those men familiar with the affairs of the Society, and at the same time of an elective group which brings new men to counsel in affairs of the Society. This makes a representative body of the Society—forty-six—which is active at the regular meetings when the policies for the ensuing year are determined. It then becomes the duty of the Executive Committee to carry out these policies.

November Meeting

On November 21, 1928, there was an informal meeting of members of this Society who were attending the annual meeting of the Land Grant College Association. This meeting was held in the Willard Hotel, Washington, D. C. The meeting was held for the purpose of advising the President and the Secretary on the work on personnel which might be assigned to the Institutional Division; the work of the Board of Investigation and Coordination; to secure action, if necessary, to have the list of engineering schools together with the names of administrative officers published in the Educational Directory issued by the Bureau of Education; and to investigate the expense attached to this Society joining the American Engineering Council. There were thirty-seven members in attendance.

Classification of Engineering Colleges

There is a persistent demand from various sources such as national engineering societies, educational organizations, individuals, etc., that this Society undertake to classify engineering colleges. The matter has been before this Society at different times but always with a negative reaction. Your Secretary suggests that this matter be thoroughly discussed by the Council and that a recommendation be made to the Society.

Publications

The present income of the Society limits the amount which can be expended for printing to about $6,000 annually. This includes The Journal of Engineering, the bound volume of the Proceedings, and the year book. Of course, this sum is wholly inadequate. A sum of $25,000 could be easily and profitably used if we should include adequate editorial assistance. A large part of the editorial work now falls upon the Assistant Secretary who does it in a very competent way, in addition to all the other work which she must do.

Journal of Engineering Education

The number of articles presented for publication in The Journal is always in excess of the space available. The Publication Committee selects those articles which it believes will be the most useful to the greatest number of members. Unfortunately, many articles must be held for some time even after they are in galley. Many must be rejected. The policy which the Publication Committee follows meets with the approval of many of the members. One of our members recently wrote: "It is an extremely valuable publication in its field and holds consistently to a fixed editorial policy, namely that of excluding all material extraneous."

The section of The Journal devoted to College Notes is of interest to everyone because of its personal character. We are in hopes to develop this to a much greater extent. See to it that your institution is represented. Your friends like to know what you are doing and it may be just the thing they

need to develop their work. Do not overlook the small things. They make up the whole.

Almost every number of THE JOURNAL has an article which appeals to some teacher, dean, or president, and he writes for sufficient reprints or copies for his friends or colleagues. These are seldom available because the extra numbers printed must be small to keep within the budget.

YEAR BOOK

The year book is published as a supplement to the May number of THE JOURNAL. This is necessary because our mailing permit calls for ten numbers of THE JOURNAL. We would not, therefore, be permitted to mail the year book as an eleventh number. The type used for the year book is held from year to year and the necessary changes made each year. The printer advises us that the type is now worn out and cannot be used again. The Publication Committee will suggest to the Council that a different type be used which will materially reduce the cost,—a change which we could not afford while the old type was standing.

Postcards are sent to each member each year upon which he may indicate any changes in his position or address. The copy for the year book is prepared from these, supplemented by information which may be available in the secretary's office. The year book should be accurate. However, any errors which you see should be corrected and sent to the office of the secretary, University of Pittsburgh.

PROCEEDINGS

From the organization of the Society, in 1893, until September, 1910, the only publication of the Society was the Proceedings which contain the report of the annual meeting together with all papers and discussion. In 1910, a monthly bulletin of the Society was begun which contained papers, reports, etc., which were not presented at the annual meeting. The Proceedings were published also. In 1925, the By-Laws of the Society were changed and "a bound volume

of the JOURNAL for each current year shall constitute the Proceedings of the Society. Volumes of the Proceedings will be sold to members who subscribe for them at a cost to be determined each year by the Executive Committee. Subscriptions for the Proceedings must be received in advance by the Secretary on or before October 15 of each academic year."

In July of each year we circularize the membership for subscriptions to the Proceedings. Each year the number of orders received is smaller and this year 167 subscriptions were received, the smallest order of any.

DIVISIONS

Institutional Division: Last year the Institutional Division was reorganized under the leadership of Dean C. E. Magnusson of the University of Washington. Dean C. C. Williams of the University of Iowa is the chairman this year and he has appointed three committees: Committee on Personnel Instruction, R. L. Sackett, Chairman; Committee on Coordination of Preparatory and Engineering Education, T. M. Focke, Chairman; Committee on Graduating Personnel, A. M. Greene, Chairman. A meeting of the Division is scheduled for Thursday afternoon, June 20, at which time these committees will make their reports.

In order that the work of the Division might not be hampered by lack of funds, the Board of Investigation and Coordination appropriated $1,000 to defray expenses of the investigations.

Early in the fall the president of each institutional member was asked to appoint a member of his faculty, preferably the dean of engineering, this appointee to be the representative of the Society in that institution. The names of those so appointed are printed in italics in the year book after the name of the institution.

DRAWING DIVISION: At the North Carolina meeting a group of teachers of drawing presented to the Council a petition to form a division of drawing. The Council approved this request and the Drawing Division, under the chairmanship of Thos. E. French, has been very active this year.

PHYSICS DIVISION: At the close of the summer school on Physics at the Massachusetts Institute of Technology in 1928, a Physics Division was formed and later approved by the Council. W. N. St. Peter is chairman of this Division.

The organization of these divisions is a very interesting growth in the Society. This Society, being organized of men and women interested in engineering education, must necessarily be general in its meetings and in its publications. The separation into divisions assists the member in that he has the opportunity to talk over his problems with others in the same field. At the same time he is keeping abreast with the latest developments in other branches of engineering education by his contacts with those in fields other than his own. At this meeting there are conferences of these three divisions as well as by those members interested in civil, electrical and industrial engineering, English, and engineering problems and orientation. No regular session is scheduled at the time of these conferences so that each member in attendance at the meeting may attend a meeting of his own choice.

I believe that these sections can do much more than they have to promote, in every way, engineering education in their localities. Each section should have a standing committee on this subject. Meetings of teachers of high and preparatory schools should have in attendance official representatives of sections of this Society. Local engineering societies should be encouraged by the sections to have at least one educational meeting each year. Meetings should be arranged with representatives of industry. Closer cooperation with meetings of other types of college education would tend to the betterment not only of engineering education but possibly of other types of college education.

There are now eleven sections and branches of the Society, and there is opportunity for more. The secretary will assist in organizing such sections. Reports of sectional and branch meetings are published in the JOURNAL of the Society. They should be forwarded to the secretary immediately after each meeting.

Lamme Award

The first award of the Lamme medal was presented to George F. Swain at the North Carolina meeting in 1928. The choice of the Committee, judging from the many comments made by different members to the Secretary, met with unanimous approval.

The Committee, which selects the recipient for the award each year, sent blanks to each member of the Society and to the president of each engineering school asking for nominations together with a brief history of the nominee. These blanks were returned to the assistant secretary who made abstracts of the life sketches of fifty-eight nominees made by more than 160 persons. These abstracts were sent to the Committee on April first. The Committee will make its report of the recipient for the second Lamme medal at the Columbus meeting, Thursday, June 20, 1929. Mr. C. S. Coler is Chairman of the Committee.

Board of Investigation and Coordination

The investigatory work of the Board will be completed by September 1, 1929. At that time Mr. Wm. E. Wickenden, who has been Director of Investigations since 1923, will assume his duties as President of the Case School of Applied Science. The Society was fortunate in having Mr. Wickenden to direct the investigation for the past six years. He has made an outstanding contribution to engineering education and the Society extends its best wishes for his continued success at Case.

The bulletin on the study of European colleges will be issued. This is a most valuable addition to the reports which have been issued from time to time.

All the reports of the Board will be bound and distributed as the final report.

For the past year the Board has been conducting a study of non-collegiate technical institutions. It is the plan of the Board now to print in the fall numbers of the Journal of Engineering Education reports on this study. Tentative reports will be made at this meeting by Mr. Wickenden and Mr. Spahr.

Due to the resignation of Mr. Wickenden, the full responsibility of the summer schools has been transferred to Mr. H. P. Hammond.

Your Secretary believes that the Board of Investigation and Coordination should be continued indefinitely, or as long as there appears to be a need for it. It is composed of men who have seen years of service in the field of engineering education; men of mature judgment and keen vision; men who are primarily engaged in broadening and enriching engineering education. They have been loyal servants of the Society for the Promotion of Engineering Education.

Summer Schools

One of the outstanding results of the investigation which has been conducted by this Society for the past six years was the need for better teaching. It was suggested by Mr. Hammond that summer schools for engineering teachers be established under the auspices of this Society. After a thorough discussion of this subject the matter was presented to the Carnegie Corporation and they made an appropriation of $7,500 for the first year. The first schools were in the subject of mechanics and were held at Cornell University and at the University of Wisconsin. Last year, two schools were conducted, one in electrical engineering at Pittsburgh, and one in Physics at the Massachusetts Institute of Technology. This summer a single school only is being conducted at Purdue in mechanical engineering. The funds for the last two years have been raised by subscriptions, the Carnegie Corporation contributed last year $2,500. It has recently made an appropriation of $10,000 for the general overhead for the continuation of these schools for a period of five years. One of the outstanding features of these schools is the fact that the number of applicants exceed the number that can be accepted. As an outgrowth of the school on mechanics, there is being held a conference of mechanics teachers following this annual meeting. Not only do those who attend benefit but the interest manifested extends throughout the whole country.

American Engineering Council

The Secretary believes that this Society should be a member of the American Engineering Council. This Council is doing a very important work for the engineering profession. Engineering Education, forming the basis of the engineering profession, should function as an integral part of this Council. Steps were taken at the informal meeting of this Society on November 21, 1928, to forward this movement. The main question is one of finances. It is out of the question to increase the dues of this Society in order to join the Council. The Council's committee is at work trying to devise some means by which they can afford to have this Society become a member. In this connection a study was made on January 1, 1929, of the number of members of the Society for the Promotion of Engineering Education who belonged to the national engineering societies. Of course not all of our members could belong to the national engineering societies since we have in our membership teachers of modern languages, English, mathematics, etc. However, fifty-two per cent of our membership are members of those national engineering societies which are members of the American Engineering Council. Twenty-six per cent of our members who are qualified to become members of those engineering societies do not belong. As a matter of interest I give below a table showing the number of the S. P. E. E. who are qualified to belong to those national engineering societies but do not.

Statistics Concerning Membership in Societies

Members of S. P. E. E. who do not belong to National Engineering Societies:

	Civil	Electrical	Mechanical	Mining	Total
Dean and Directors ..	3	1	1	1	6
Professors	43	16	19	3	81
Associate Professors .	15	7	6	2	30
Assistant Professors .	49	11	27	1	88
Instructors	15	18	16	..	49
Not members of Nat. Societies	125	53	69	7	254

Committees

The work of the committees of this Society should be especially commended. It is not expected that every committee will present a report every year but each year we find certain committees presenting exhaustive reports on special phases of engineering education. The funds available for this committee work are very small, the amount is only $150 per year for all committees. Due to the great interest and loyalty of the members of the committees to engineering education much is accomplished. For instance the Committee on Civil Engineering, under the chairmanship of Professor A. H. Fuller, has been working for three years and this year will present a very exhaustive report on civil engineering,—15 pages of printed material. There would have been many more pages if the funds of the Society had been adequate to permit the publication of all the material that should have been printed.

Annual Meetings

Many members of the Society hardly appreciate what it means to have the annual meeting at an institution. As soon as the Society has accepted an invitation from an institution, a local committee is formed which plans for the meeting. The amount of work involved, the matter of rooms, meeting places, hotel accommodations, entertainment, etc., is enormous. The local committee under the direction of Wm. T. Magruder has devoted a very large amount of time to making your stay at this institution pleasant and profitable. The institution at which the meetings are held derives intangible results. A greater proportion of the faculty can attend the sessions than could afford the time or money to go to another institution.

The Secretary has represented the Society at the following meetings: Highway Education Board, Washington, D. C.; American Council on Education, Washington, D. C.; American Society of Mechanical Engineers, Rochester, N. Y.; New York-New Jersey Section of the Society. He also had a conference with President Kimball at Ithaca, N. Y.

In order to expedite the work of the office, it was necessary for the assistant secretary to visit the New York office, to visit the printer at Lancaster, Pa., and to visit The Ohio State University in connection with the program for the thirty-seventh annual meeting.

After the Secretary's report was written, he read it over and it sounded a good deal like a famous New England policy on economy. But I think we must remember that this Society is now one of the larger national engineering societies. Its dues are exceedingly low. Its total budget is only $11,000 a year, over half of which must be immediately absorbed for printing. So far as the Secretary can see the work must be handled as at present with a part-time secretary and an assistant secretary. The work of conducting such a Society involves a tremendous amount of correspondence, editorial work and general administration. The financial records alone are almost sufficient to take the time of one individual. The Society could well use a full-time secretary, a full-time editor, and at least three assistants, but this would involve a budget of something like $35,000 a year. So I think that the Secretary should be pardoned for laying emphasis on the subject of economy.

THE 1929 SESSION OF THE SUMMER SCHOOL FOR ENGINEERING TEACHERS

PURDUE UNIVERSITY, JULY 1, 1929

(Read from left to right.)

TOP ROW—H. E. Rosseli, U. S. Naval Academy; F. S. Egilsrud, Pratt; B. G. Elliott, Wisconsin; G. L. Tuve, Texas Technological College; R. E. Puerner, Wisconsin; L. Washington, Lehigh; C. M. Merrick, Lafayette; C. G. Thatcher, Swarthmore; H. F. Gauss, Idaho; L. D. Crain, Colorado Ag.; P. A. Willis, Missouri School of Mines; L. Blumberg, Delaware; H. C. Gray, Rose.

FIFTH ROW—D. B. Porter, N. Y. U.; H. F. Roemmele, Cooper Union; C. A. Sjogren, Nebraska; W. W. Carlson, Kansas Ag.; L. R. Bridge, Pittsburgh; W. S. Ayars, Columbia; J. P. Calderwood, Kansas Ag.; L. L. Amidon, West Virginia; Douglas Baker, Newark College of Engineering; H. L. Mason, Rutgers; W. W. Edwards, Wentworth; H. W. Blackburn, Syracuse; W. R. Halliday, Stevens; C. A. Koepke, Wyoming; G. F. Yott, No. Dakota Ag.; R. M. Dolve, No. Dakoa Ag.; V. R. Yates, Vermont.

* Died August 2, 1929.

FOURTH ROW—A. W. Cole, Purdue; C. W. Larson, Worcester; L. P. Porter, Pratt; P. J. Zimmers, Case; J. R. DuPriest, Minnesota; J. A. Brooks, Newark; J. G. Fairfield, Rensselaer; W. R. Woolrich, Tennessee; L. A. Wilson, Wisconsin; Paul Bucher, Ohio State· F. W. Marquis, Ohio State; L. G. Miller, Des-Moines; Ross Winship, Valparaiso; E. L. Lucas, Mississippi Ag.; E. H. Sager, Washington University; S. D. Barclay, Pratt; A. V. Kilpatrick, Missouri School of Mines; R. W. Lindley, Purdue; Leo Holdredge, Tennessee.

THIRD ROW—J. B. Peddle, Rose; H. J. Lockwood, Dartmouth; D. H. Shenk, Purdue; B. E. Fernow, Clemson; M. A. Lee, Cornell; N. M. Hall, Manitoba; E. V. N. Kennedy, Renssalaer; Fred S. Griffin, Akron; J. A. Lambertine, Brooklyn Polytechnic; C. A. McKeenan, Case; H. D. Watson, Maine; C. E. Bullinger, Penn. State; R. E. Summers, Oregon Ag.; J. H. Gill, W. Virginia; E. H. Beckstrand, Utah; C. E. Davies, A. S. M. E.; H. S. Cameron, Pratt; A. J. Ferretti, Northeastern.

SECOND ROW—E. F. Garner, Cornell; J. B. Baker, New Mexico; R. L. Anthony, Yale; J. C. Ashby, Louisville; G. A. Stetson, A. S. M. E.; F. C. Stewart, Georgia Tech.; I. M. Fraser, Saskatchewan; S. E. Winston, Armour; E. Anderson, Nebraska; Jiles W. Haney, Nebraska; O. K. Harlan, Penn. State; C. Wischmeyer, Rose; F. L. Eidmann, Princeton; A. A. Luebs, Nebraska; * E. Robinson, Vermont; J. W. Ingalls, Northeastern; F. E. Mehrof, Rutgers; G. N. Moffat, Ohio State; W. E. Reuling, Michigan State College.

FRONT ROW—(Staff) G. H. Young, Purdue; H. L. Solberg, Purdue; F. O. Ellenwood, Cornell; H. P. Hammond, S. P. E. E.; C. H. Judd, Chicago; D. S. Kimball, Cornell; A. A. Potter, Purdue; Arthur J. Klein, (guest); G. W. Munro, Purdue; R. C. H. Heck, Rutgers; O. A. Leutwiler, Illinois; O. W. Boston, Michigan.

THE 1929 SUMMER SCHOOL FOR ENGINEERING TEACHERS

BY A. A. POTTER, *Local Director of the Session*

The 1929 Session on Mechanical Engineering was held at Purdue University, June 27th to July 18th, 1929, and was attended by 88 engineering teachers who represented 60 institutions located in 36 states of the United States and 2 provinces of Canada. These teachers included 3 deans, 30 professors, 14 associate professors, 16 assistant professors, 24 instructors and 3 of other ranks. The staff comprised 23 teachers who came from 13 engineering colleges; also 27 engineers, directors of research and industrial executives who represented 15 leading manufacturing and public utility industries. In addition to the 88 members of the Conference and the 50 of the staff, a few others attended as auditors and the following guests were present during one or more meetings: David E. Ross, President of the Board of Trustees, Purdue University; Calvin W. Rice, Secretary, American Society of Mechanical Engineers; Erich Oberg, Treasurer, American Society of Mechanical Engineers; George T. Seabury, Secretary, American Society of Civil Engineers; William S. Monroe, Arthur M. Houser, Joseph B. Armitage, and D. B. Charters representing the A. S. M. E. Standardization Committee; R. I. Rees, President, S. P. E. E.; J. A. Davidson and J. W. Skinkle of the Western Electric Company; Arthur J. Klein, Chief of the Division of Higher Education, Bureau of Education of the U. S. Department of the Interior; and Charles F. Scott, Chairman of the S. P. E. E. Board of Investigation and Coordination.

The program was carried out in accordance with the original plans. All of the staff members whose names were reported in the January, 1929, issue of the JOURNAL OF ENGINEERING EDUCATION were present as scheduled and only one

substitution had to be made. In practically every case outlines of the lectures, prepared in advance by staff members, were ready for distribution at the beginning of each meeting. Also in most cases complete manuscripts of the lectures were prepared in advance by staff members, although very few read their lectures. The generous cooperation of engineers and industrial executives in the program of this Session is an indication of the interest American industry has in engineering education.

A special feature of the program was a three-day trip to Chicago where fourteen engineers and executives of the Western Electric Company, the American Telephone and Telegraph Company and the Illinois Bell Telephone Company gave a notable series of lectures on the organization, engineering production, inspection, purchasing, cost control, material handling and storage, personnel practices, and development problems of modern industry. Three afternoons were spent in the Hawthorne plant inspecting methods and processes which illustrated the lectures given during the mornings and evenings.

The major part of the Session was attended by the entire group, but twelve divisional meetings were devoted to heat power, machine design and production. The general meetings were devoted to the following topics:

Lectures on general educational principles and practices were given by C. H. Judd of the University of Chicago and Edward C. Elliott of Purdue University. These included the psychology of the learning process, general principles of teaching, how to conduct lectures and recitations, trends in higher education, variables of teaching in technical schools, personal elements of efficient instruction and teaching methods in general. Both Dr. Elliott and Dr. Judd stressed the importance of humanizing higher education, urged every teacher to become fully acquainted with the preparation and aptitudes of the students in their classes, and encouraged deliberate experimentation to discover better teaching methods.

To provide a background for engineering instruction the historical aspects of mechanical engineering were discussed by

William D. Ennis of the Stevens Institute of Technology, Ira N. Hollis, Former President of the Worcester Polytechnic Institute, J. W. Roe of New York University and John Johnston, Director of Research of the United States Steel Corporation. Through the generosity of the Engineering Societies Library rare books dealing with the history of engineering were available for consultation during the Session.

The purposes and scope of courses in heat power, machine design, production and laboratory practice were outlined in lectures at the beginning of the Session; these were followed by special lectures on the methods of teaching particular subjects such as thermodynamics, heat power machinery, kinematics, automotive engineering, machine design, machine drawing, shop practice, mechanical engineering laboratory and management. Much interest was exhibited in the plan used at the Massachusetts Institute of Technology for teaching such subjects as thermodynamics to large groups of students. The use of the demonstration lectures in place of some routine laboratory tests was discussed. The use of a single textbook for advanced engineering subjects was questioned.

Special lectures were delivered on college personnel methods, materials in machine construction, applications of mechanics to machine design, methods of stress analysis, administration of mechanical engineering departments, and research.

Coupled with the general and divisional meetings a series of lectures on advanced phases and applications was delivered by noted authorities in the general fields of mechanical engineering. In this list were included lectures on heat power by C. F. Hirshfeld of the Detroit Edison Company, E. G. Bailey of the Fuller-Lehigh and Bailey Meter Companies, C. H. Berry of Harvard University, F. O. Ellenwood of Cornell University, Edward F. Miller of the Massachusetts Institute of Technology and W. J. Wohlenberg of Yale University; the mechanical engineering problems in aviation were discussed by Edward P. Warner formerly of Massachusetts Institute of Technology and former Assistant Secretary of the Navy; trends in material handling were taken up by Harold V. Coes

of Ford, Bacon and Davis; lectures on internal combustion engine design were delivered by H. A. Huebotter of the Waukesha Motor Company and C. B. Veal of the Society of Automotive Engineers; trends in machine tool design were discussed by E. A. Muller of the King Machine Tool Company; lectures on trends in prime mover design were delivered by H. F. Schmidt of the Westinghouse Electric and Manufacturing Company; lectures on the fundamental principles of machine design were given by O. A. Leutwiler and H. F. Moore of the University of Illinois, S. Timoshenko of the University of Michigan, and R. C. H. Heck of Rutgers University; lectures on the advanced phases of production were delivered by D. S. Kimball of Cornell University, L. P. Alford of the Ronald Press Company, J. W. Roe of New York University, E. Gruenewald of the Ross Gear and Tool Company, and O. W. Boston of the University of Michigan.

One whole day was devoted to a consideration of the teaching of engineering economics, values and costs. At this meeting, G. M. Williams, President of the Marmon Motor Company, discussed the factors which must be considered in financing manufacturing enterprises.

Several evenings were devoted to special lectures and discussions. One of the most outstanding of these was a symposium of the influence of standardization on the mechanical industries, which was conducted under the auspices of the A. S. M. E. Standardization Committee.

An important part of the Conference was the preparation of committee reports by those in attendance. The committee reports approved at the 1929 Session included: Prerequisites in Mechanical Engineering Curricula, Student Inspection Trips, Heat Power Courses for Non-mechanical Engineers, Purposes and Methods of Design Courses, Aims and Methods of Shop Courses, The Teaching of Values and Costs, The Teaching of Management Courses, The Teaching of Personnel Administration, and Mechanical Engineering Laboratory Instruction. These will be published in the October, 1929, number of the JOURNAL.

The recreational features included an informal smoker on the opening evening, an over-night excursion to the Turkey Run Indiana State Park, a Fourth of July picnic at the Ross Camp (the Purdue University Civil Engineering Camp), and a closing dinner on July 17th. At the Turkey Run State Park, Richard Lieber, Director of the Department of Conservation of the State of Indiana, gave an address on "The Services of the Engineer in the Development of the Public Estate." David E. Ross, President of the Board of Trustees of Purdue University, Edward C. Elliott, President of Purdue University, John Johnston, Director of Research of the U. S. Steel Corporation and C. F. Scott of Yale University, spoke at the closing dinner.

Nearly the entire group including all of the staff members and guests was housed together at the Franklin Cary Hall, a new dormitory of Purdue University. Members and guests accompanied by their wives were assigned to suites of rooms in the same dormitory. The Franklin Cary Hall, while providing unusually ample and fine facilities for the entire group, afforded excellent opportunities for the informal exchange of ideas and the formation of friendships between those in attendance. Very few of the staff members limited their contact with the members of the Conference to the days they delivered their lectures, but the majority either came earlier or remained longer in order to participate in the social and formal parts of the program. Contact between staff and conference members brought about a better understanding on the part of the entire group of the conditions in more than 70 engineering colleges of the country. Social contacts outside of the sessions were fully as valuable as the formal portions of the program. The presence of the officers and representatives of the A. S. M. E., S. P. E. E., and of the Western Electric Company also added to the success of the Session.

The *A. S. M. E. News* for July 22, 1929, in commenting upon this Session makes the following statement:

"The Session was a highly stimulating experience for all those who attended and it should have a far-reaching effect

on the teaching of mechanical engineering throughout the country. The opportunity to compare experiences, to hear the great men of the teaching profession and to become acquainted with the leaders in engineering and industry in the short space of three weeks was indeed a rare one."

If the 1929 Summer School for Engineering Teachers will result in better teaching of mechanical engineering subjects, the agencies which cooperated in this undertaking will be fully rewarded for their efforts.

REPORT OF COMMITTEE ON RESOLUTIONS TO THE S. P. E. E. SUMMER SCHOOL FOR ENGINEERING TEACHERS, MECHANICAL ENGINEERING SESSION, AT PURDUE UNIVERSITY, JUNE 27–JULY 18, 1929

The 1929 Summer Session on Mechanical Engineering has been a thorough success. We have been privileged to sit at the feet of masters of teaching, leaders in engineering and industry. We have enjoyed the informal interchange of experience between members of the session. The inspiration we carry away has lifted our task from the plane of mere teaching to the higher one of molding men. We are grateful to many individuals and organizations for the extremely valuable results of this session:

To the Society for the Promotion of Engineering Education and its various agencies for the Summer School idea which focused attention on the importance of good teaching as a factor in engineering education which seemed in danger of being overshadowed by the emphasis being placed on research and contact with industry, and to H. P. Hammond, Director of the Summer School, whose vision, sound educational knowledge, careful planning and patient, quiet supervision have made the Summer School scheme a vital force in engineering education.

For these successful sessions at Purdue, individual mention must be made of those whose contributions were direct and valuable:

Purdue University and President Elliott, who placed the splendid facilities and comfortable surroundings at our disposal during our pleasant stay and whose happy spirit of cooperation helped tremendously in the success of the session.

Dean A. A. Potter, Local Director of the sessions, whose dynamic leadership and generous, wholehearted hospitality made this 1929 Summer Session a complete success. The

splendid group of lecturers, busy with their own affairs, who painstakingly distilled the essence of their experience and knowledge and sacrificed their time and energy to bring it to us in person inspired us to a more fruitful fulfillment of our teaching tasks; the members of the mechanical engineering faculty of Purdue University who devoted much time and effort to the details of the conference and their wives who in countless ways made us at home in their midst; the Indiana Conservation Commission and Colonel Richard Lieber who entertained us so bounteously at Turkey Run Park on our pleasant holiday; the Ross Gear and Tool Company who revealed to us their methods and operations and thereby gave us a valuable bit of background for the engineering instruction we impart.

In Chicago for three days the Engineering Summer School was the guest of the Western Electric Company in a session of instruction of great value to the mechanical engineering teachers of the country. The Western Electric Company opened its treasure of knowledge and experience that we may better train our students in the business of life. We learned of the intimate problems of engineering and of personnel from busy executives who are leaders in the solution of these problems in a great industry. The American Telephone and Telegraph Company, through General R. I. Rees, and the Illinois Bell Telephone Company, through Mr. G. B. West, made valuable contributions to the success of this portion of the program.

To all these men and organizations who have contributed so wholeheartedly to our mental stimulation and physical comforts, we express our deep appreciation. The courtesy and kindliness of our new friends in this great organization will ever be with us.

In Chicago, we were also entertained by the Commonwealth Edison Company at the Crawford Avenue plant. We enjoyed especially the kind guidance of Mr. A. E. Grunert.

Finally, we are deeply appreciative of the support and sponsorship given to the Summer School enterprise, and through it to engineering education at large, by the profes-

sional body of engineers as is evidenced by the generous financial contribution of the American Society of Mechanical Engineers.

We leave this session with a fine feeling of fellowship in our profession and a profound gratitude to all those who aided in its planning and conduct.

Committee,
B. M. BRIGMAN,
F. W. MARQUIS,
C. E. DAVIES.

July 18, 1929.

This report was adopted by acclamation at the final session of the Summer School for Engineering Teachers on July 18, 1929.

JAMES WATT *

By IRA N. HOLLIS

Former President, Worcester Polytechnic Institute

It would be too much of a task to present the life of James Watt to this audience in the sense of bringing out anything new. No historical figure has ever left a greater amount of material upon which to base a biography. Furthermore he was very fortunate in his friends while alive and most fortunate in those who have endeavored to bring together all the events and facts of his life and inventions. His kinsman Muirhead wrote an excellent biography of him. He also collected his letters and the specifications of all his patents in a three volume edition. The best biography, however, was prepared for the hundredth anniversary of James Watt's death, by H. W. Dickinson and Rhys Jenkins. It contains an excellent bibliography. All that I could say of the events of his life would be a mere repetition of what any reader can find in this volume. I shall, therefore, direct attention to the influences that made Watt what he was, and the influences that he transmitted on to the next generation.

One of my friends, a profound student of psychology, said to me last winter that humanity advances by steps, and not by the slow process of evolution. He illustrated this with many examples showing that great advances, or changes, were brought about by men of abnormal types. He cited the revolution in Russia with the unspeakable Rasputin as perhaps the exciting and immediate cause. It may be that leadership is dependent on abnormality, if we take the definition of the word in the sense of exceptional character and quality. It is my belief, however, that the world has advanced more under

* Presented at the Summer School for Engineering Teachers of the Society for the Promotion of Engineering Education, Purdue University, July 16, 1929.

the influence of men of normal, sane tendencies. Certainly the two greatest names in American history are George Washington and Abraham Lincoln.

It is rare that we can prophesy what will be the influence of any man upon the next generation. Who would have dreamt of comparing James Watt with Napoleon Bonaparte? These two men lived as contemporaries in the latter part of the eighteenth century and the first part of the nineteenth. The first had no publicity except amongst a few professors and business men who knew about his work. The second was known to the whole world. By his insensate ambition he planted the seeds of hate and revenge in the hearts of many millions of people, who will become friends only as the memory of Napoleon Bonaparte fades away. His influence related almost entirely to political matters which are always in a state of flux, and when he died in exile the world was well rid of an evil force.

On the other hand James Watt died in honor at a good old age, loved and mourned by his countrymen from the King down to the lowest commoner. By teaching us how to turn heat into energy he created a new world for humanity, and he did it in such a quiet way that no one dreamed at the time that he had really opened the door to opportunities for all men. When Napoleon died his achievements were already broken, and his political arrangement of Europe had already gone to pieces. When James Watt died the fruits of his labor were just beginning to ripen, and their seeds were being planted for a new kind of harvest lasting probably through all the future of man's history. Can we argue from these two examples that man's advance has any real relation to abnormality? Can we not rather see that our progress is determined in the main by men of normal, sane character who work mainly for the benefit of others?

Humanity will always be interested in the sensational. Like children, men want to be surprised or startled, and that is why the ordinary events of what we might call daily routine are taken as a matter of course. The newspapers have never attempted to present the events of peace in any but an emo-

tional and startling aspect. When I told a reporter many years ago that the Columbia's engines had such power that they would hoist a three hundred pound weight out of a mine one mile deep with such velocity that it would leave the earth's attraction entirely he was not interested, but when I added that they would hoist Grover Cleveland out of a mine one mile deep with such velocity that he would be eliminated entirely from the coming presidential campaign he not only overflowed with interest, but rushed off to telegraph his paper in New York all about it. It is written in the nature of man that he will always be like a child.

The first and most profound influence of James Watt was the stimulus to all forms of invention. New ideas commonly have to wait for their fulfillment until the time is ripe for them. In some cases that is very far in the future. The steam turbine, for instance, was two thousand years old before we had the workmanship and the materials to make it possible. The same thing is true of the use of the steam generator which remained a dream through the centuries.

I am tempted to dwell on the real place of the steam engine in the progress of mankind, in order to bring out its significance to future generations. It was the beginning of a new era so fundamental in its character as to change the mental power of men. The first great invention was some kind of a cutting tool. That perhaps did more to turn the early man of undeveloped mentality into man as we know him today than anything else. In the history of invention fire and agricultural processes are often mentioned as crucial inventions. Both were important and made their contribution to man's progress, but the absolutely essential fact that distinguished him from the beast and freed him from dependence upon teeth and claws was the cutting tool. Thousands of years elapsed, perhaps millions, before he supplemented his hand and body with energy derived from the outside. He tamed a few animals for domestic purposes and for transportation, he made use of the wind for power to drive his ships, and finally he discovered that water could be employed in driving machines. These things brought him to the middle of the

eighteenth century. Then came the great awakening and this new era that I have referred to. We do not yet know what its significance may be. Through it we have changed the character of man's work and to some extent we have freed him from toil, but we have not released him from poverty and misery and war.

James Watt was born in Greenock, Scotland, on the 19th of January, 1736, and he died on the 19th of August, 1819. He came of a fine Scotch family, generally well-to-do and intelligent. There was always a leaning towards mathematics amongst the men. His greatgrandfather was a farmer near Aberdeen, killed in battle during the wars of Montrose. He left a son of tender years who was carried off by relatives to a little town near Greenock where he grew up. The grandfather, Thomas Watt, was thus born into a time of civil wars. He became a teacher of mathematics in and around Greenock. He was a man of substance, well respected and yet he became very nearly deprived of a license to teach because he had not taken the oath. Later he became chief magistrate of his district, and he was much concerned with public works of all kinds. As baillie, he had to inspect the morals and behavior of the citizens. His son James Watt and the father of the younger James was a shipwright by trade and then a merchant. He too, was baillie for a term of thirty years.

James Watt's mother was Agnes Muirhead. To her he probably owed his imagination and his desire for study. She taught him reading and was described in her part of Scotland as a braw woman, "none like her to be seen." That he needed such a mother is plain from his physical weakness. He could never share the sports of other boys, and his early education was mostly at home. He was subject to fits of despondency and discouragement all his life, and he probably was a victim of what the psychologist calls "the inferiority complex." He always underrated himself and at times felt like giving up. It is commonly supposed that he was a man of one idea, but quite the contrary is true. He was so good in civil engineering that he took naturally to public work, and at one time he almost decided to give up the thought of the steam engine, be-

cause he could not make a living, in order to go into the surveying of canals and the development of the Clyde. He might have been like Scott, a great writer of stories, for he knew the tales of the Scottish border through wandering across the hills among the farmers and shepherd folk during his youth. He might have been a geologist or chemist or even a linguist if he had had any early education to fit him.

We as teachers have something to learn from the early career of a man like Watt. He practically made himself with a little prod now and then from friends. He is a fairly good proof that genius is not born in colleges. There may come to every student in our schools an awakening as to the possibilities within himself, and there undoubtedly is acquired the power of work, and of mental abstraction. But James Watt is a perfect illustration of the fact that self-education is just as valuable if not more valuable than any college education that can be given.

It will be worth while to refer occasionally to James Watt's friends, for many were interested in him. He must have had that generous, open character and that modesty that naturally drew people to him, and gave them a desire to help. While he did not go to the university he came much under the influence of its professors. The first of these was Dr. Dick. Watt had gone up to Glasgow looking about for something to do, as he had to contribute something to the family living. It was perfectly natural for him to think of nautical instruments as his father and grandfather had both dealt in them, but there was trouble for him in Glasgow. There were no good instrument makers and besides seven years were required for an apprenticeship. Dr. Dick advised him to go to London to learn the trade. It is probable that Dr. Dick, who was professor of natural philosophy at the University of Glasgow, needed just such a man, and this looked like an opportunity to favor a boy and to get himself a satisfactory workman. He gave James a letter to some friend in London, and this friend brought him to the attention of John Morgan, an instrument maker. It cost twenty pounds for one year's instruction under Mr. Morgan and then James Watt was ready to begin his career as an

instrument maker. It speaks volumes for his intelligence and skill that he became a first class workman during that short period. Upon his return to Glasgow, Dr. Dick again befriended him. He could not set up a shop in Glasgow because he had not complied with the apprenticeship rules, but fortunately the university was independent of the city and within its walls the trade guilds had no power. When, therefore, Dr. Dick gave him a room in which he could set up his little shop he had begun the train of circumstances to be ended only with our nineteenth century of industrial change. There was not much living in the trade of instrument maker however, and James Watt turned his hand to nearly anything that came along. The first job was the setting up of a collection of astronomical instruments from Jamaica. Dr. Dick started him in October, 1756, and paid him five pounds for cleaning and refitting these instruments. In mid-summer of 1757, just after he was twenty-one years old, he received the appointment as mathematical instrument maker for the University. Dr. Dick had died and he came under the friendship and perhaps the chief influence of his life, John Robison, afterwards professor in the University of Edinburgh. This friendship was so unusual and Professor Robison's life was so interesting that it is worth while to say a few words about him. He was three years younger than Watt and came into his workship when he was a student. He must have made many suggestions to Watt and their conversations were doubtless of a character that marked that particular workshop. Watt himself was a natural born teacher and student. He became the center about which many of the discussions, both political and industrial took place. His hand and mind proved a quickening touch for almost everything. One of the curious illustrations of this is that a friend came in one day to show him a double pen for making two copies of the same manuscript at the same time, exactly like that invented by Thomas Jefferson years afterwards for use in his own home at Monticello. Watt told him to wait until the next day and he would bring him in an improvement. He did, and that is the origin of the common letter press. Going back to John Robison, he succeeded Pro-

fessor Black in the University in 1766, but soon after he went as secretary to Admiral Knowles on the Russian Board of Admiralty. He had been a midshipman in the British Navy. He was at the battle of Quebec and was on duty in the boat that took General Wolfe on an inspection trip the night before his army stormed the heights. After he was appointed Professor of Natural Philosophy at Edinburgh, he wrote the history of the steam engine in one part of his four volume book on mechanical philosophy. Although an inspiring friend he was also a crank, for he wrote a lot of stuff on the supposed conspiracy against all religions and governments by the free masons.

The story of Watt's starting out as a boy with certain notions about steam derived from watching the lid of a teakettle is probably as apocryphal as the cherry tree and the hatchet. He may have thought very little of the power of steam except as one of the professors suggested to him the possibility of driving a road wagon by steam power. This was Professor Robison; but the man who really introduced Watt to the subject of steam was John Anderson whose name is of some importance to teachers of engineering and of technical science. It was he who endowed the college that afterwards became the technical school at Glasgow. He studied at the University of Glasgow and was appointed Professor of Oriental Languages. Then four years later, in 1760, he changed and became Professor of Natural Philosophy. His chief interest seems to have been the application of applied science to improvements in the mechanical arts, and one of his main activities was the scientific instruction of operative mechanics. It may well be that his acquaintance with James Watt, who afterwards found so much difficulty in getting workmen skillful enough to make the earlier engines, led him to see the necessity for wider opportunity to obtain proper training for mechanics. He invented a gun whose recoil was taken up by compressed air, which he presented to the National Convention in Paris. It is not necessary to describe his many interests. He left his estate to the establishment of a university in Glasgow for technical and scientific education, but he made such

unlimited specifications with regard to mathematics, Latin, Greek, Hebrew, French, music and medicine that it was impossible to carry out his endowment. It was turned into the Anderson Institution for instruction for the humblest workmen. It was practically the origin of mechanics institutes throughout the world.

Professor Anderson had sent to London for the return of a model of the Newcomen engine which had been there for repairs. It had fallen into indifferent hands for it had lingered two years without any repairs, and it must have occurred to someone to let Watt try his hand. Probably Professor Anderson thus gave him his chance. The model was brought back to Glasgow and he began to study and experiment with it to see why it did not run. This introduced him to the study of steam. It did not take him long to find out that the loss of heat by injecting cold water into the cylinder and by leakage destroyed the effectiveness of the machine. He made experiments to determine the quantity of cold water or condensation and in his own way discovered latent heat, which Dr. Black had determined before him. It was then but one step to the invention of the separate condenser and air pump. This constituted the real beginning of his improvement upon the Newcomen engine, but before going on with any description of the patents taken out in consequence let us consider briefly his relations with Dr. Black. There has been much misunderstanding about that and many have made the mistake of attributing the invention of the steam engine, or rather its improvement into a workable machine, to Dr. Black's discovery of latent heat. The two men were warm personal friends and remained attached to each other all their lives. Joseph Black was born in France of Scotch parents. He studied medicine in Glasgow and was a practicing physician. Only eight years older than Watt, he seemed to be very much drawn to him from the very beginning of the work shop and his methods as a careful investigator must have meant much to James Watt, who learned from him the value of research. It is probably not too strong a statement to say that Watt thus became one of the first research engineers. The common mis-

take is that Dr. Black's determination of latent heat had something to do with the invention of the separate condenser. That is not true, as stated by James Watt himself in a letter forming the preface to John Robison's four volume edition on physics. In 1814, he was called upon to revise the articles on steam and the steam engine in the Encyclopedia Britannica, and he wrote to Dr. Brewster a letter intended to correct the wrong impression: "Here it was my intention to have closed this letter; but the representations of friends whose opinions I highly value, induce me to avail myself of this opportunity of noticing an error into which not only Dr. Robison but apparently also Dr. Black has fallen in relation to the origin of my improvements upon the steam engine, and which not having been publicly controverted by me has I am informed been adopted by almost all subsequent writers upon the subject of latent heat. . . . Dr. Robison in the article on the steam engine after passing an encomium upon me dictated by friendship qualified me as the pupil and intimate friend of Dr. Black. He afterwards in the dedication to me of his edition of Dr. Black's lectures upon chemistry goes the length of supposing me to have professed to owe my improvements upon the steam engine to the instruction and information I have received from that gentleman, which certainly was a misapprehension, as though I have always felt and acknowledged my obligations to him for the information I had received from his conversations, and particularly from the knowledge of the doctrine of latent heat, I never did nor could consider my improvements as originating in those communications." This letter is too long to quote fully. It is extremely interesting and Watt goes on to tell the whole story ending up with the following paragraph: "Although Dr. Black's theory of latent heat did not suggest my improvements on the steam engine, yet the knowledge upon various subjects which he was pleased to communicate to me, and the correct mode of reasoning, and of making experiments of which he set me the example, certainly conduced very much to facilitate the progress of my invention; and I still remember with respect and gratitude the notice he was pleased to take of me when

I very little merited it, and which continued throughout his life."

There is another common mistake in regard to James Watt. A well known historian found me looking over a lot of books in the library and asked what I was doing. I told him I was looking up the life of James Watt. "Who was he? Oh, yes, the inventor of the steam engine." He was not the inventor of the steam engine, and he never claimed to be. He is accurately described on the monument in Westminster Abbey as, "James Watt who directing the force of an original genius early exercised in Philosophic Research to the improvement of the steam engine, enlarged the resources of his country, increased the power of man, and rose to an eminent place among the most illustrious followers of science and the real benefactors of the world." This inscription so careful and moderate in tone is one of the best in the English language, and it certainly states with accuracy James Watt's claim to a place in the Abbey among the great.

At the time that James Watt conceived the notion of a separate condenser he had no thought of power for manufacturing. It was a pumping engine for the mines that he had in his mind. Such engines were needed all over England and Scotland. A vast amount of experimentation was required before he got beyond the discouragement of failure after failure. His main trouble sprang from the absence of good mechanics and good material. At that time it was difficult to make a true cylinder, and still more difficult to keep the piston tight. His character is well brought out during the period from 1765 when he first thought of the separate condenser of 1769 when he took out a patent covering the condenser and other improvements to the Newcomen engine. Through spells of depression, discouragement, and lack of money he nevertheless persevered. I doubt if the modern engineer can quite grasp the conditions that faced him. Research had not come to be the panacea for all things in science, and few men thought of deliberate and careful investigation as the determining factor of improvement. It was fortunate for Watt that he was so much in contact with the professors in the University. He

learned from them far more than he would have found in books, and he proceeded along the line "that a problem once correctly stated is more than half solved." He was far more than a mechanic in this respect, and he did not hesitate to undertake anything that would reveal the hidden causes to him. He learned German and Italian in order to read books on science and machinery.

The chief obstacle towards his improvements was money. He had to earn a living and to find the means of building an engine of sufficient size for a trial in the mines. There was also the anxiety of keeping quiet about it as he had not taken out a patent at the time that his first engine was completed. Fortunately for him, Dr. Black again came to his rescue and introduced him to Dr. Roebuck, the owner of the Carron mines. Dr. Roebuck needed engines to get the water out of the mines, and he went into partnership with Watt, apparently agreeing to stand all expenses in return for two-thirds of the patent. The first engine was a failure and the partnership never did yield anything to Dr. Roebuck. In fact he found himself in great financial difficulty and had to sell out.

The first application for a patent, which was granted by the British Parliament, describes his apparatus as "a method of lessening the consumption of steam, and of fuel in fire-engines." There were a number of specifications; the first related to keeping the cylinder hot by means of a steam jacket; the second stated that the steam was to be condensed in vessels distinct from the cylinder; the third was the air pump for removing condensed steam and air from the separate condenser; the fourth simply improved on the first specification by putting steam into both ends of the cylinder so as to remove the atmosphere from contact with the internal surfaces; it also advocated exhaust into the atmosphere where water was not available for condensing; the fifth was devoted entirely to a rotary engine connected direct to a rotating shaft (it may be said here that this was never a success and that it has never been improved into an efficient engine for developing power); the sixth is not very clear, but it seems to contemplate using steam expansively; the last specification related entirely to

the piston and other parts of the engine in motion, and the substances used for keeping the piston tight.

It will be observed that Watt had almost all the ideas that were afterwards perfected into the modern engine. The only other patent that we need to refer to here is the mechanism by means of which reciprocating motion was converted into circular motion around an axis. The specifications for this simply enumerated different methods for accomplishing it. He was debarred from using the ordinary crank and axle by the fact that a patent had been taken out by James Pickard, applying these to Watt's engine. It seems curious that Parliament allowed such patents to be taken out, as Mr. Watt says in one of his letters, "The real inventor of the rotative motion was the man, be he Chinese, Indian, Arabian, Greek or Goth who first made a common foot lathe." He had planned to use it as far back as 1771, but it never occurred to him to take out a patent. He further says, "Finding the door thus closed upon us, and circumstances making us unwilling to go to law with the patentee, which could only have had the effect of throwing the invention open to the public if we had succeeded, we judged it better to let it remain with them who did not seem capable of doing us much harm." All engineers know that instead of the crank and axle he used the well known sun and planet wheel by means of which a shaft makes two revolutions for every double stroke of the piston. Perhaps a more important part of this patent relates to the use of the fly-wheel, the function of which seems to have been perfectly clear in Mr. Watt's mind.

Other patents were taken out and will be found well described in the three volumes of James Watt's letters and patents published by Mr. Muirhead. My main thought here is to bring to your attention the fact that after James Watt had once taken hold of the model in Glasgow University he never let go until he had suggested every element of the modern engine, including two cylinders.

James Watt's life is a good illustration of the fact that invention is after all a philosophy requiring the same kind and power of thought as literature or art. That is why he was

always thought of by his contemporaries as a great philosopher. Certainly Watt was filled with ideas on every subject. He had no great knack for business affairs and he had no money for research.

The real business man behind the development of the steam engine as a commercial machine was Matthew Boulton who was about eight years older than Watt. He was an English business man in Birmingham, having established himself at Soho just outside of the city. He manufactured all kinds of metal objects, especially of an artistic nature, and it is likely that his first interest in James Watt was to get motive power for his machinery. The partnership between the two, making the firm of Boulton and Watt, was formed in 1774, five years after the first patents were taken out. Mr. Boulton bought out Dr. Roebuck and Watt moved to Soho. This was a most happy friendship in business, each one of the men having a distinct function to fill in the growth of the steam engine, first for pumping and then for industrial purposes. Mr. Boulton died in 1809, just ten years before his partner. A third man in this company is seldom mentioned. He was William Murdock to whom the firm owed the training and the direction of skilled mechanics. He was a devoted friend and servitor, and the success of the firm was in a very large measure due to his technical skill.

At the time the first patents were taken out the English patent law was not very clearly defined. A long suit followed which was finally decided in the favor of Boulton and Watt along about 1796. It is probable that this litigation served to clear up some of the misunderstandings about patent rights and to put the English patent law in such a shape that America could make use of it.

Let us go back to inquire into what kind of a world James Watt made his start. When he undertook the steam engine he had already spent some time in civil engineering, and, in what is astonishing beyond measure, in the making and repairing of musical instruments. He had undertaken to make an organ for the masons in Glasgow without ever having studied music and worse still without any ear for music. By a

study of the theory and by reading everything he could get on the subject he made out to construct a superior organ with improvements. This brought him work in repairing violins, flutes and perhaps in making musical instruments. He might have left us violins as good as the Strativarius had be persevered.

In the middle of the eighteenth century the world had apparently wakened up. The writings of Rousseau gave an impetus towards the desire for individual liberty. All France was plunging towards the abyss which culminated in the complete breakdown of the divine right of kings. America approached and passed the Revolution which separated her from Great Britain, and the way was opened to the great developments politically and industrially which have followed. England was ready for the great change which turned her into an industrial empire. She needed transportation for her colonial empire; she needed power to make use of the new machines for spinning and weaving; and above all else she needed pumps for the mines. In Scotland, especially in Glasgow, there came a thirst for the development of trade. One of Watt's early projects was the improvement of the Clyde so as to make Glasgow a seaport. We might say that only an impulse was needed to start the wheels of the world. It almost seemed that fate was thus propitious for the obscure and poor mechanic to become the great figure of modern times.

At the time the steam engine appeared, Adam Smith who was a friend of Watt, had begun his work on the wealth of nations. Arkwright had taken out his patent on the spinning jenny and the scientists had begun to think about the meaning of heat. Small water powers had been set up, but all forms of industry were handicapped by the lack of prime movers.

As I have already stated, this is in no sense intended to be a history of the steam engine; it is rather the career and influence of a man. The chief obstacle to the development of a satisfactory machine was probably the lack of good mechanics. The world had changed during the Christian era and hand skill had gone backwards. An Egyptian mechanic could have taken a piece of very hard stone and turned it into a hollow

sphere one-eighth inch thick with a small hole for the insertion of the tool. The dimensions and shape were exact. We may call this marvelous, and it was, but why were England and Scotland so far behind that they could not bore a cylinder true enough to keep a piston moving within it even reasonably tight?

There is another question that many students have asked. Why did the model of the Newcomen engine not work? Such engines had been effective in the collieries; that is, effective enough to pump water with some interruptions. These engines were not steam engines in the strict sense of the word, they were atmospheric engines and the steam was used simply to produce a vacuum below the piston. The trouble with the model on which Watt began his work was that it was too small. It does not require much demonstration to show that the smaller the diameter of the cylinder the greater the relative amount of cool surface exposed to the steam entering from the boiler. That is why the Glasgow model choked up after a very few strokes and stopped. It is probably fortunate for mankind that the professors found this little engine of no use, because this very great loss of heat in the small cylinder put into Watt's mind the necessity for a separate condenser. It is curious that Watt never seemed to understand the effect of clearance volume upon the expansive use of steam. He did know the value of a steam jacket, and he did understand fully that heat was to be conserved, but it remained for an American, Corliss, to bring out the relation of reduced clearance to efficiency.

There is one thing that stands out very plainly, that is, that the use of steam engines required heat. At that time the whole theory of heat was wrong; science was proceeding along a blind alley. Heat was conceived to be some kind of a substance squeezed out of materials when work was done upon them. There was no thought of friction turned into heat energy. It was absolutely necessary to revise the theories of physics in order to explain the steam engine. Two or three searchlights had been thrown upon nature by Newton and Galileo, but the key to science was lacking until, as stated in the Encyclo-

pedia Britannica, "The rapid development of the steam engine in England during the latter part of the eighteenth century had a marked effect on the progress of the science of heat." The writer might have added that it had had a very great effect in giving science a rational foundation. There is no doubt that the disappearance of heat in the process of doing work was a fatal blow to the old caloric theory. James Watt's study and invention thus directed thought along new lines. He devised an indicator for recording the change of pressure in using steam expansively and he undoubtedly knew well that heat was used up in doing work; perhaps he noted also that it might be passed into other forms. His patent in 1782 shows an indicator diagram and the gain in using steam expansively more than forty years before the correct thermodynamic laws were stated by Carnot. He had determined the total heat of steam and constructed some elementary tables long in anticipation of Regnault's tables. His use of foot-pounds and horsepower gave us the units for our calculation. One of Carnot's findings was, "The motive power obtainable from heat is independent of the agents employed to realize it. The efficiency is fixed solely by the temperatures of the bodies between which in the last resort the transfer of heat is effective." In other words, he, as a scientist, at last recognized the fact that heat was energy more than fifty years after Watt's first patent. Thus a new generation had to be born and grow old before the revolution in physical concepts had been completed. It is, then, not too far fetched to say that the formula, *heat is energy,* is the key to modern industrial and scientific thought. Perhaps it is also the builder of a new kind of man on this earth. While Watt succeeded in making a good working machine and suggested most of the elements involved in the improvement of the modern steam engine, he never did attain great economy in the use of coal. For one thing, he had not the boilers for high pressure, and for another he does not seem to have thought of superheat or clearance. Furthermore the laws of heat as stated by Carnot, a scientist of the first rank, were needed to develop the true theory of heat engines and to provide an agency capable of turning a considerable fraction of heat into work.

The first influence of Watt's invention was in the tremendous stimulus it gave to all other forms of invention. By the use of power the way was opened to an infinite number of applications. The end of this is not even in sight, perhaps hardly more than begun. Naturally the first effect was upon England and Scotland. There the coal and iron mines started on their development that made England the first manufacturing country in the world, at least until the United States of America reached their fuller development in the use of raw materials. Arkwright and Hargreave had already invented machines for the textiles. All that was needed was power to change domestic manufactures into mass production, and this changed England from an agricultural country into an industrial empire. It is not necessary for me to dwell here on what this has done for mankind. We know already. The indirect effect upon the United States is almost like a magical change. The new mills created a demand for cotton, and the invention of the cotton gin that followed almost immediately turned slaves as well as cotton into a profitable crop; then followed the great struggle in our own country that culminated only in the Civil War, and Lincoln's proclamation of freedom.

M. Arago, the great astronomer and physicist, called Watt "the creator of an engine destined to form an epoch in the annals of the world." In no respect does this seem so true as in transportation. Its effect upon the Clyde is a sufficient illustration of the change that has taken place over the entire world. The invention of the locomotive, which after all is the use of a steam carriage on rails, has completely changed the social, the economic and the industrial aspect of the world. We know that, and we know furthermore that it has tied together forty-eight states into a great Republic that probably could never have existed without the steam engine to bring men nearer together. We are so accustomed to rapid communication that we hardly ever stop to think of its effect upon the supply and distribution of food and clothing. In Massachusetts alone fully half the population would die of starvation before the state could catch up with the agricultural needs, if the railroads were suddenly to stop. The colonies

after the American Revolution could never have supplied one another without transportation vastly superior to anything that existed in those early days. It is very interesting to note here that one of George Washington's chief interests was the promotion of canals as a means of putting the first thirteen states into communication with one another. I think it was he who first proposed the Erie Canal across New York State. He was president of a company for one of the early canals. In reaching out towards the west, the Ohio river has become historic as a channel of communication for the pioneers going into the dark and bloody ground. They could go down the river with the current, but could not come back again. With the coming of the railroads our whole country has opened up to the pioneer who has turned the wilderness into plowed land across the entire continent. We as engineers know well what the locomotive and steel rail have done for mankind.

The next place where the influence of steam upon transportation is found lies upon the sea. The marine engine might be called peculiarly a Scotch machine although the first successful steamboat for commercial purposes was made by an American, Robert Fulton. That is why so many marine engineers are Scotchmen. I have seen them the world over in English, American and foreign ships. That is why McAndrew's hymn is so moving an appeal to all Scotchmen and I might add too, to all American engineers. The railroads have banished famine in the United States and the steamships have gone far to banish it from the entire earth.

One of the most vivid illustrations of the influence of steam upon transportation is found in Mr. Carnegie's little book on the life of James Watt. When Watt undertook the journey from Glasgow to London for the purpose of spending his apprenticeship with John Morgan he went horseback for twelve days. Mr. Carnegie says of this, "The member of Parliament in Watt's day from the north of Scotland would have consumed nearly twice twelve days to reach Westminster. Today if the Capitol of the English-speaking race were in America, the members of the great council from Britain could reach Washington in seven days." If he had only known

what the use of power in the air was going to do for the English-speaking race he might have said that the members of the great council from all parts of the earth could reach Washington in a week; certainly they could reach Congress in less time, much less time, than it would have taken them to assemble in session from the United States alone one hundred years ago.

The most powerful influence of energy outside of the human body made available on a great scale by the final completion of the steam engine, and by the many inventions that have followed in its train, may lie in a domain wholly unexpected. It may affect man's very nature both mentally and spiritually through the freedom from toil. This is not a fanciful idea, although at the present time our outlook is not very encouraging. We still have poverty and misery about us due to the hard conditions of life. Thousands of men have been taken off the farm and put into the mines; other thousands have gone into the unending labor of the factories. We know perfectly well that a machine directed by one man can do the work of many hands. A well known illustration of this is found in the ginning of cotton at the close of the eighteenth century. One man replaced two hundred when the machine came in, and cotton became king. A rough calculation based upon the power of all our prime movers would make the potential population of this country many thousand millions to supply the need of one hundred and twenty millions. The trouble with this estimate is that it does not seem to fit. If a fraction of the population can supply the wants of all what are the others doing? A number of questions spring out of this thought. Is the work of the world fairly divided amongst men? Is man going to learn how to apportion his labor to his reasonable needs and to do his share, thus leaving the leisure gained to something better than amusement, luxury, display and the worst of vices, the killing of time by men and women who have never learned how to use their minds and bodies properly.

The social life of James Watt is interesting although not very much is to be found about it. In Birmingham he was a

member of the Lunar Society, a company of highly distinguished men who met *once a month* to discuss all kinds of subjects. He was a man very much sought after, and we get a good picture of him in his old age from the tributes paid by his friends of long standing. Sir Walter Scott said about him: "Amidst this company stood Mr. Watt, the man whose genius discovered the means of multiplying our national resources to a degree perhaps even beyond his own stupendous powers of calculation and combination—bringing the treasures of the abyss to the summit of the earth—giving the feeble arm of man the momentum of an Afrite—commanding manufactures to arise, as the rod of the prophet produced water in the desert—affording the means of dispensing with that time and tide which wait for no man—and of sailing without that wind which defied the commands and threats of Xerxes himself. This potent commander of the elements—this abridger of time and space—this magician, whose cloudy machinery has produced a change on the world, the effects of which, extraordinary as they are, are, perhaps, only now beginning to be felt—was not only the most profound man of science, the most successful combiner of powers, and calculator of numbers, as adapted to practical purposes—was not only one of the most generally well informed, but one of the best and kindest of human beings." "Methinks I yet see and hear what I shall never see or hear again. In his eighty-second year, the alert, kind, benevolent old man had his attention alive to everyone's question, his information at everyone's command. We discovered that no novel of the least celebrity escaped his perusal, and that the gifted man of science was as much addicted to the productions of his native country, in other words, as shameless and obstinate a peruser of novels as if he had been a milliner's apprentice of eighteen." A lady whose autobiography survives says of him: "He was one of the most complete specimens of the melancholic temperament. His head was generally bent forward while leaning on his hand in meditation; his shoulders stooping and his chest falling in, his limbs lank and unmuscular, and his complexion sallow. His intellectual development was magnificent. His utterance

was slow and unimpassioned, deep and low in tone, with a broad Scotch accent, his manners gentle, modest and unassuming. I can speak from experience of his teaching me how to make a dulcimer and improve a Jew's harp."

Thomas Campbell said of him, "Watt is now eighty-three; but so full of anecdote that I spent one of the most amusing days that I have ever had with a man of science and a stranger of my own pursuits."

The most splendid tribute to him was written by Lord Jeffrey who had been a friend for many years. Referring to his steam engine he says: "It is our improved steam engine that has fought the battles of Europe . . . it is the same great power which now enables us to pay the interest to our debt. But these are poor and narrow views of its importance. It has armed the feeble hand of man with a power to which no limits can be assigned, and laid a sure foundation for all those future miracles of mechanic power which are to aid and reward the labors of after generation. It is to the genius of one man that all this is mainly owing; and certainly no man ever bestowed such a gift on his kind. The fabled inventors of the plow and the loom, who were deified by the erring gratitude of their rude contemporaries, conferred less important benefits on mankind than the inventor of our present steam engine. This will be the fame of Watt with future generations. But to those to whom he more immediately belonged, who lived in his society and enjoyed his conversation, it is not perhaps the character in which he will be most frequently called—most deeply lamented—or even most highly admired. Perhaps no individual in his age possessed so much and such varied and exact information—had read so much or remembered what he read so accurately and well . . . that he should have been minutely and extensively skilled in chemistry and the arts, and in most of the branches of physical science, might perhaps have been conjectured, but it could not have been inferred from his usual occupation, and is probably not generally known, that he was curiously learned in many branches of antiquity, metaphysics, medicine and etymology, and perfectly at home in all the details of architecture, music

law. He was well acquainted too with most of the mod-
languages, and familiar with our most recent literature.
was it at all extraordinary to hear the great mechanician
engineer detailing and expounding for hours together the
physical theories of the German logicians or criticising
measures or matter of the German poetry." One could
ote quotations indefinitely but it is all epitomized in
minster Abbey where Lord Brougham has placed "the
lapidary inscription in the English language" as a
e to James Watt's service and memory.
es James Watt's life shed any light upon the modern
m of education? We are probing everything now. Our
people are writing books on every phase of American
and foreigners have come to investigate us and to report
us as a phenomenon. It is said that sixty commissions
different countries have come to the Department of
merce to get their start into a study of American life.
are interested in why and what we are. It is an attempt
r part and on the part of foreigners to reduce us to
ics. Are we trying too much of the same thing in regard
cation? That is very difficult to answer, but we cer-
are investigating. James Watt is a perfect example of
the great careers in modern times without any stimulus
a school, unless his contact with professors in Glasgow
ersity afforded him a far better education that he ever
have obtained in crowded class rooms. There every-
is standardized, and the variety of minds that go in are
ed to come out as standard products. It is doubtful if
chool or college training is really adapted to the excep-
young man or woman. Would James Watt have im-
the steam engine if he had been a college graduate?
it is doubtful. There is much to be said for the college
in those branches of science reduced to mathematical
la. Certainly the development of electrical engineering
me from a type of mathematics and research that has
for far more education than was required by the devel-
of the steam engine. Nevertheless in all this we are
to define the word education and to state how it can

best be obtained. James Watt died one of the best educated men in all England, and yet he had been to school only for short periods and he never had been to college. Almost all of his work was of such a practical nature that it required more skill and experience in the handling of material than in the knowledge of physics; but when he needed science or literature towards accomplishing his end, he had no hesitation in undertaking anything. He undertook it as he needed it. We usually demand too much and too great a variety of subjects on the part of students as a means of putting them in touch with everything. One of the theories of Harvard University is to give a student some little knowledge of everything and some considerable knowledge of something. I wish there were some college in this world where students could go with complete freedom to educate themselves.

In a paper written for the *Forum* by James Adams, attention is called to the statement of Gibbons that his years at Oxford had been the most unprofitable of his career and to the belief of Henry Adams, the historian, that his four years at Harvard had been wasted. Mr. James Adams, himself, seems to imply that his own college years were unproductive. He studied Latin, German and French at school and at the end he could not speak more than one sentence of any of them in conversation. Yet at the age of thirty-five he taught himself more Persian in a few months than he had ever learned of Latin by years of drudgery. Again I can ask the question what would a college education have done for James Watt? It probably would have trained him for some routine position in teaching, engineering or in business.

This is a serious question before educators and it cannot be answered by saying that a genius will clear the way for himself and that standardized education is for the routine men. I well recall the remark of Justice Brandeis years ago when the question of combining Harvard with the Massachusetts Institute of Technology came up. He said education ought not to be too much standardized. There is plenty of room in this country for different methods and different colleges. I wonder if that is not true of our engineering schools.

One of the curious aspects of our modern psychology is the determination of the youth's fitness entirely through examinations for information and not by a study of hereditary influence and the surroundings of the boy. What college pays much attention to-day to the ancestry of a boy or girl who comes up for entrance? Could James Watt have gotten in to an American College? Probably not; and yet that does not dispose of the question of his education. Perhaps he could not have made his great contribution to human knowledge if he had started out in the year 1929. We always have to take something like that into consideration in comparing the influences that produce men in different ages. His power came from his inheritance, from the conditions around him and from his fearlessness in undertaking anything that came into his mind. The boyhood of James Watt was spent in a part of Scotland keenly alive to the new influences, and he was only following the line of least resistance when he obeyed the urge of his inheritance and his surroundings. The trouble over the Stewarts and Covenanters had passed and the claymore was put aside so that Watt and his family had time to think of something else besides forcing human beings into conformity. The moral that I draw from this is that a boy has a better chance of real education by contact with good teachers and good influences than in the ordinary mental drill, and that was perhaps James Watt's education. He never became a good business man, for he cared little about money beyond making a living for his family, and from boyhood on he came under the influence of the best minds of his day. He had passed through a delicate childhood fortunate beyond most men in his friendships. In all things oscillating between enthusiasm and despondency he was well understood by his wife who once wrote him, "if the engine will not do, something else will; never despair." His own estimate of himself is perhaps the best expression of his quality. He had in Soho a good friend in Dr. William Small, who, by the way, had been a professor in the University of Virginia before going back to Scotland. Watt wrote to him in 1773: "Man's life, you say, must be spent either in labor or ennui; mine is spent in both.

I am heart sick of this country, I am indolent to excess, a
what alarms me most I grow stupider. My memory fails
so as often totally to forget occurrences of no very anci
dates. I see myself condemned to a life of business; noth
can be more disagreeable to me; I tremble when I hear
name of a man I have any transactions to settle with.
engineer in business is not a vigorous plant; we are in g
eral very poorly paid."

I am tempted here to add something more on the subject
invention. It is like everything else, a consequence and no
miracle. Perhaps there are no miracles in nature. The m
profound truth that I know is that everything is a con
quence of what preceded it. The steam engine is a very g
illustration of this. It began with the Egyptians and is p
haps not finished yet. The minds of men all through the c
turies going back through the ages were turned naturally
some method of avoiding work, to some method of generat
power outside of the human body. That is exactly what
steam engine represents. The common idea that inventi
spring new into the thoughts of ignorant persons or into
dreams of the genius is wrong. They are evolutions follow
in the footsteps of one another. As I have already said th
nobody can fairly be called the inventor of the steam eng
and of the idea that came out of it, "Heat is energy."
the same way the cutting tool has been an evolution.

The progress of invention has been far more of an art th
a science up to the latter part of the eighteenth century w
the study of mathematics, physics and chemistry laid b
what might be called the laws of matter and forces. Si
1800 science has been the improver of inventions as it has b
the origin of many inventions in the last fifty years. T
good examples bring us the difference between an art an
science. The completion of the steam engine was unquesti
ably an art, and little science was required in devising
separate condenser. The invention of the electric dynamo
a science derived from Faraday's experiments in the lab
tory. We have a tendency in our day to make a fetish
science. An instinctive knowledge of the equilibrium of fo

and of the laws of motion carried mankind through perhaps a million years to the generalisation of Gallileo and Newton. Then a few centuries brought us to the greater generalisation that heat is energy and gave us the basis for real science in invention. Once the road has been pointed out by the inventor, science has been the explorer.

One of the serious questions that we may ask ourselves today is whether the steam engine has done too much for us, and made of future centuries a dizzy debauch of luxury. Are we, as Mr. Wells asks, like the spoiled child who has received too many birthday presents? Perhaps it may be the engineer's job to solve our present day problems that have sprung out of his own work. It does not necessarily follow that comfort and luxury turn men into degenerates, yet there is something of that tendency, and our own attitude of mind towards wealth, social position and even towards crime leaves us much to think about. Here we have through the use of power everything that reasonable human beings can desire, and it is our task to see that there is no effort wasted on useless things and that luxury does not set up another caste system in this country where every man ought to have his opportunity intellectually, spiritually and materially.

There is a consolation to be found in the public spirit of many Americans of wealth. We are in the habit of calling this a mechanical, material age. The philosopher and the artist generally decry it as the century of materialism. Yet no age in all history has shown a greater craving for spirituality than will be found in the United States at the present time. No people in the world have ever been so ready to give as our people. A quiet obedience to the draft of all young men during the late war is another very strong evidence that we are not sinking into another crass, material age.

Two questions have been asked in reference to modern developments in industries. What would have been the source of power today in case the steam engine had never been invented? Is this present wave of prosperity unparalleled throughout the world to continue? Unfortunately neither of these questions can be answered in a very satisfactory manner.

Certainly something would have come out of the urge for material and political progress during the middle of the eighteenth century. The curve was ascending and something would have been devised to give man energy outside of his own body even if the steam engine had been delayed. It could not have failed to arrive at the hand of some other man, if Watt had not taken hold in 1765. We have very nearly as futile a question in the request to know what will come next. The gasoline engine has replaced the steam engine for automobiles and the steam turbine is very rapidly replacing it for the generation of power to be used on a large scale. The atom is held up to us as a possible reservoir of energy, but we do not know.

In answer to the second question, the world has seen many periods of prosperity like this. The Roman Empire at the height of its power was not unlike the United States today. Prosperity is after all like the third wave which recedes to be succeeded by smaller waves. Mr. Hoover has touched upon the possibility of stabilizing prosperity. Perhaps that can be done, but the crash must come some day unless we can standardize population to prevent its overtaking the means of support.

This brief review of James Watt's life and influence cannot be dismissed without a few words about his relations to people around him. It would almost seem that fate had marked him out for the task of bringing power to the attention and use of mankind, and for that purpose had not only endowed him with understanding of things, but also with the singular attraction that drew men towards him in the desire to help and to promote his ambitions. He had great influence over all with whom he came in contact, from the Scotch Gillie of the Highland to the most highly placed men of the whole kingdom. The last chapter of Mr. Muirhead's book is well worth reading on account of the many touching quotations from the friends and acquaintances of James Watt after his death. Reference has been made to Walter Scott, but many others mourned him and spoke of him. It is a very striking fact that the King and his ministers felt very strong

regret that he had never been recognized in any public way during his life. They began that public subscription which placed his statue in Westminster Abbey and contributed the tablet written by Lord Brougham.

In his retirement, he was occupied with all kinds of interests from public works to inventions, and his last solicitude was to have a good machine for copying statuary. He actually succeeded in making a fine copy of the bust of Sappho. It is a curious turn that this master of realities should have been interested in giving us copies of this mistress of poetry, but then it was a perfectly natural outcome of Watt's development into spirituality and artistic taste.

There is no doubt but that Watt began the system of prizes for the best papers written by students. He gave the University of Glasgow 300 pounds sterling, the income of which was to be used as an annual premium on papers contributed by students. There are many such prizes all over the world now, but I want to call attention to the curious coincidence of Charles T. Main's first gift to the American Society of Mechanical Engineers for prizes on the influence of engineering. It was exactly the same amount as James Watt gave to the Scotch University.

Is it fanciful to believe that in course of time James Watt might have become as legendary as the man who stole fire from the gods and gave it to mankind, and who thus became the friend and benefactor of the race. But for the printing press this undoubtedly would be his lasting memorial. As a man who taught us how to turn heat into energy he is the most important figure of history during the Christian era. The poet Wordsworth said of him: "I look upon him as perhaps the most extraordinary man that this country ever produced."

Let this be his epitaph.

BRIEF CHRONOLOGY OF JAMES WATT

1736, Jan. 19	Born at Greenock, Scotland.
1755, June 7	Set out for London at the suggestion of Dr. Robert Dick.
1756, August	Returned to Greenock after one year's apprenticeship with John Morgan, instrument maker.

1756, Fall	At Dr. Dick's request repaired and set up the astronomical apparatus that had been sent to the University from Jamaica.
1757, Summer	Opened a shop within the precincts of the University of Glasgow where he became Instrument Maker to the University.
1757	Introduction to Dr. William Black, professor of the practice of medicine, Glasgow University.
1758	Acquaintance with John Robison and John Anderson both of whom became life-long friends.
1759	Attention first directed to the use of steam by John Robison who remarked on the possibility of moving road wagons by a steam engine.
1759–1765	Partnership with John Craig and hard work in a variety of occupations including surveying to make a living.
1759	Moved from his college room to a shop on Salt Market Street, Glasgow.
1761	Experimenting with steam but attention diverted to other matters until the Newcomen model was taken in hand.
1763, winter	Model of the Newcomen engine given to him for examination and repairs.
1763	Construction of two organs like those for churches.
1763–1769	Continued experiments to determine the following: 1. The capacity of heat of iron, copper and wood compared with water. 2. The volume of steam compared with that of water. 3. The quantity of water evaporated by a pound of coal. 4. The pressure of steam at various temperatures and an approximation to the law which it followed at other temperatures. 5. The quantity of water in the form of steam per stroke by a small Newcomen engine with a wooden cylinder six inches in diameter and twelve inches stroke. 6. The quantity of cold water per stroke for condensing the steam in a cylinder.
1764, July	Married to Miss Margaret Miller.
1765	Invention of apparatus for drawing in perspective.
1765	Invention of the separate condenser.
1767	His attempt to build an engine for the collieries

stopped from lack of money and his relief by Dr. Roebuck with whom he formed a partnership.

He went to London about the canals and on the return was introduced to Matthew Boulton by William Small.

Jan. 5 The first patent taken out called a "Method of lessening the consumption of steam and fuel in fire engines." This was in litigation for nearly thirty years, until adjudged in favor of Boulton and Watt. Briefly the specifications covered the following points:

1. Keeping the cylinder hot by means of a steam jacket.
2. Condensing the steam in a vessel distinct from the cylinder.
3. An air pump for removing the condensed steam and air from the separate condenser.
4. Admitting steam into both ends of cylinder after putting cover on what had been the atmospheric end of the Newcomen engine. Exhaust into the air where water was not available.
5. A rotary engine called a steam wheel connnected directly to the shaft. (Never improved to a success).
6. The use of steam expansively.
7. Keeping the piston and rod tight by means of oil, wax, resin, fat, mercury and metal parts.

1773 On account of the failure of his first engine and his discouragement he turned to civil engineering as a way of making a living. He made surveys of several canals and directed the construction of one, being in a fair way to become highly successful in this branch of engineering. He also devised a screw propeller for the propulsion of boats.

Death of his wife from whom one son survived to old age.

On mutual agreement and payment to Dr. Roebuck, then insolvent, the partnership was dissolved and transferred to Mr. Boulton. Thus was formed the firm of Boulton and Watt in Soho near Birmingham.

During the civil engineering period he took out a patent for new types of clocks and watches, made a micrometer for measuring distances with a telescope, and a new surveying quadrant.

Patents extended for twenty-five years.

Married to Anne Macgregor.

1780, Feb. 14	The second patent was a new method of copying letters. It became the common letter press as we know it.
1780	Invention of a machine for drying linen by steam.
1781, Oct. 25	The third patent was a method of applying the reciprocating motion of the piston to produce circular motion. The sun and planet wheel was the result as a patent on the ordinary crank had anticipated its use with the steam engine.
1782, Mar. 12	The fourth patent seems to be in part a repetition of claims in the first patent on account of infringements. 1. Expansive action shown by an indicator diagram. 2. The double-acting engine. 3. The double engine with two cylinders. 4. Toothed rack for guiding the piston rod. 5. The steam wheel. 6. A number of mechanical improvements for equalizing the distribution of power. Among these was the fly wheel.
1782	Discovery of the constituent parts of water. A long controversy followed as to who really discovered it.
1784, Apr. 28	The fifth patent includes: 1. Parallel motion for guiding the piston rod. 2. Balancing the moving parts. 3. Tilt hammer. 4. Portable engine (anticipating the locomotive) and atmospheric exhaust.
1785, June 14	Improved furnaces for smoke consumption. Anticipation of nearly all the theories of combustion.
1785	Elected Fellow of the Royal Society, London.
1786	Visit to Paris for the purpose of studying the Machine of Marly and replacing it by steam engines. This machine was a hydraulic method of pumping water. As stated at the time it cost about four million pounds sterling and could be replaced by a steam engine costing ten thousand pounds.
1799	Validity of first patents established.
1804	Death of his son Gregory leaving one son, James, surviving.
Last years	These years were filled with great activity in the manufacture of his engine at Soho, in the improvement in all its parts including valves and governor and in the development of many ideas. His last invention was a machine for copying statuary.

1819, Aug. 19 His death at Heathfield.

1819 A meeting presided over by the Prime Minister of England was held to provide the means of erecting a memorial to James Watt. As stated at the time "A meeting more distinguished by rank, station and talent was never assembled to do honor to genius and to modest and retiring worth; and a more spontaneous, noble and discriminating testimony was never borne to the virtues, talents and public services of any individuals in any age or country."

THE INDUSTRIAL REVOLUTION*

By JOSEPH W. ROE

Professor of Industrial Engineering, New York University

Introduction

Engineers are taking more thought than ever before to effect of their work on society at large. It is forced upon th Everyone is conscious of a rapid change in social conditi employment and standards of living. In a few years products like the automobile and the radio start major in tries, dislodging and re-aligning vast numbers of work The cry has even been raised that invention, while enormo increasing production, has actually decreased employm No mechanical engineer can be indifferent to this situa because the machines he designs have caused it.

This is not the only period of change. A century ago land went through one so drastic that it is called the " dustrial Revolution." Our present industrial prob sprang from it. The factory system, mass production, divi of labor, trade unionism and the relations between capital labor, are clearer when we see them against that backgro from which they emerged. Every engineer dealing with chinery and the social forces which it lets loose should k something about that background. A knowledge of it is sential to a wise handling of the problems of today.

It is hard to assign a definite period to the Industrial R lution. For our purpose we may take it as covering th years from 1760 to about 1840. A short book entitled " Industrial Revolution" by Charles Beard, London, 1 which has scarcely more than 100 pages, gives a very c account of it. In the back of this book is a bibliography w

* Presented at the Summer School for Engineering Teachers of Society for the Promotion of Engineering Education, Purdue Univer July 13, 1929.

may be referred to for more extensive reading. Further references are given at the end of this paper.

Economic Conditions in England in 1760

Agriculture. The nation was largely rural. 3,600,000 out of a population of about 8,500,000 lived in the country; and their estimated annual income, £66,000,000, was more than half the total national income, £119,500,000. Most of the highways were scarcely more than trails; it took ten days to go from London to Edinburgh; the building of canals was only just beginning; railroads were of course unknown; and anything like commerce in a modern sense followed the natural waterways and the seaboard. Many of the great forests and fens of the Middle Ages still existed, and the only inland commerce was in the barest necessities of life and was carried on from town to town. More than half the land was cultivated on the system of common field tillage which was very inefficient. The condition of the agricultural laborers was comparatively good; wages ranged from 8s. to 10s. per week while the cost of board was 5s. or 6s. Rents were low; food and clothing fairly abundant. Regular wages were supplemented by earnings from spinning, weaving and lace making. The common people were born, lived and died in the same community, and education was confined to the upper classes. Each community was almost entirely self-sufficing. Wealth existed only in its simpler forms and the occupations of the common people were largely hereditary.

Manufactures. The woolen trade, which was tied up with agriculture, represented more than one-fourth of the entire exports. The cotton industry, which depended on imported raw material, had hardly more than begun. The exports were only one-twentieth of the value of wool exports. The iron industry employed perhaps 200,000 persons and centered in Sussex. It had been dwindling for years. The output in 1695 was about 180,000 tons; by 1740 it had fallen to 17,350. It is now about 1,000 times that.

The land owning class had long dominated English political

and social life. A mercantile class was beginning to make it self felt, but the manufacturers had not yet become an influential factor. Industrial enterprises, most of them in the textile industries, had *begun* to specialize, but they were mainly aggregations of domestic units, with the materials supplied by the manufacturer.

"There was little specialization in industry; foreign trade was comparatively small—workers were less dependent upon capital; trade was fairly steady because production was carried on to supply a small and well known demand. The tools required in most industries were so simple and so easily secured that they were owned by the operators, and the power utilized in their operation so largely human, that there was little need for vast aggregations of capital.—The England of the first part of the eighteenth century was virtually a mediaeval England, quiet and little disturbed by the roar of trade and commerce." Beard, p. 22.

The Great Inventions

During the next 75 years, a series of great inventions, closely related, each intensifying the effect of the others, drove a plowshare under this whole situation. Their effect was first felt in the textile industry. For generations wool, which was the chief staple of England, had been combed, spun and woven by hand implements, in the homes of the workers.

In 1738 John Kay of Bury invented the flying shuttle, which practically doubled the work of a weaver. It proved useful at once and multiplied the demand for yarn supplied by the hand wheels of the workers, so that the spinners could not keep up with the requirements.

Soon after this, Paul and Wyatt invented the rotary carding machine which facilitated the spinning, but it was not at first successful. In 1764 John Hargreaves, of Blackburn, invented the spinning jenny, whereby 30 threads could be spun at once. In 1764, and in 1775, Richard Arkwright, a barber of Bolton, invented an improved "water frame," which combined advantages of rotary spinning with Hargreaves' jenny. This was a tremendous success and put the *spinners ahead of*

the weavers. Arkwright was a hard, able, unscrupulous business man and an excellent example of the early type of manufacturer. He started using horses for power, then water, then steam; and in his long career acquired a great fortune.

In 1779, Samuel Crompton invented the spinning mule, an improvement over Arkwright's water frame, which greatly improved the quality of thread. He was too poor to take out a patent and sold the information as to his machine and method to his neighbors for about £67. He was later granted £5000 by Parliament but was unsuccessful and died in poverty.

Spinning mills, using these inventions, sprang up everywhere and spun more thread than could be woven. In 1779, Edmund Cartwright, a Kentish clergyman, *invented the power loom* which put the *weaving capacity once more even with the spinners.*

As a result of these inventions the *manufacturing capacity outran the cotton supply.* Then the invention of the cotton gin by Eli Whitney in 1792 let loose the American cotton crop which supplied enough raw material for the new facilities of manufacture. In 1784, eight bales of cotton imported from the United States, had been seized at Liverpool for false declaration on the ground that they could not have been produced in the United States. In 1791, the year before the cotton gin was invented, the United States produced 2,000,000 pounds, about 1/245th of the world's output. And of this production the United States exported about 190,000 pounds, the next year only 138,000 pounds. In eight years this export had risen to 17,790,000 pounds. In 1845 toward the end of the Industrial Revolution, the world's output was 1,169,600,000 pounds of which the United States produced seven-eighths. The present output of the United States is over 7,000,000,000 pounds which is 70 per cent of the world's production. We see, therefore, that just as the manufacturing capacity of England was tremendously augmented, Whitney's invention provided the needed increase in raw material.

Bearing directly on this situation is the development of the steam engine as a source of factory power. Steam had been applied to the pumping of mines for a hundred years;

Watt had invented his condensing engine in 1765, and built the first one about 1775. He invented the rotary engine about 1785 and applied it to the driving of textile machinery soon after. The cotton manufacturers therefore had the *producing capacity,* the *raw material* and the *power necessary* to drive the new machinery.

Closely following these later inventions came the development of machine tools. All machinery, textile and otherwise, was hand made up to 1800. In 1775, Wilkinson invented the first modern machine tool on which he bored Watt's first steam cylinders, which made the steam engine commercially successful. The work of Bramah, Maudslay, Clement, Roberts and Nasmyth, during the next generation gave us the slide-rest, the lathe, planer, steam hammer and other modern machine tools, most of them being developed in order to build textile machinery. The effect of these was to make possible the present "age of machinery" which could never have reached its modern possibilities except for machines with which to build machinery.

Finally, the development of steam navigation 1807–1820, and of railroads from about 1830, widened the markets from the immediate locality of the mills to cover the whole world.

Economic Effect of these Inventions

We have mentioned only the greatest of these inventions. Hundreds of others supplemented them. Their cumulative economic effect was revolutionary. Only a few instances will be cited.

1764, Cotton imported into England .. 3,870,000 lbs.
1841, Cotton imported into England .. 489,900,000 lbs.

We have seen the rise in importation from the United States between 1792 and 1800.

The calico sold in the Blackburn market in 1805 amounted to 1,000,000 pieces; 79 years later the exports alone amounted to 4,500,000,000 yards, exclusive of home consumption.

Woolen import rose from 2,582,000 pounds in 1790 to 8,609,000 pounds in 1800. The iron output rose from 61,300 tons in 1788 to 1,347,790 in 1839. One hundred years after

Compton invented his spinning mill there were in Lancashire alone 2,655 cotton mills with a total of 37,515,772 spindles and 463,118 power looms. The exports rose in the 22 years from 1773 to 1815, from £17,000,000 to £58,000,000.

It is true that the number of hands employed rose from 110,000 to 245,000, but this increase in employment was slow. At first, thousands of people were thrown out of employment.

As a result of improved machinery the production per hand rose from 968 pounds of yarn about 1820, to 5,900 in 1886. The last comparison gives the rise in production which represents improvements in machinery. The contrast between the old hand methods and that of 1820 would be much sharper.

Social Effect of these Inventions

England was shaken out of its comfortable, mediaeval condition. The "factory system" had come in. Thousands of workmen, unable by any amount of industry, to compete with machines, were driven from their cottages into the towns to compete against each other in an overcrowded labor market. There were no laws or moral restraints covering the new conditions. A social conscience had not come into existence. The doctrines of *laissez faire* were supreme. Employers could make any agreement with their labor and set conditions which the workingmen were compelled to accept. Labor was considered only a commodity to be bought and sold on the open market. Conditions of life were secondary to the production of wealth.

Factory conditions prevalent at that time seem now almost unbelievable. Factory buildings were old, dark, insanitary, often unsafe from overcrowding. Mill owners arranged with the overseers of the poor and after inspection of the paupers, selected the best, and shipped them to their factories to wear out their lives as slaves of machinery. There were regular brokers who furnished paupers to the mills. Pauper children were thus nominally apprenticed but in reality became slaves, receiving no wages, the poorest food, rags for clothing and worked 14 hours or more a day. They were worse than slaves—because they had no value. A negro slave in the

South had a very real value and was therefore conserved. Parliamentary reports tell of children being knocked down and beaten as many as ten times a day.

Note the following quotation from *Laws of Management,* by Alford, pages 198–199:

"In 1832 a Parliamentary committee investigated British factory conditions and on the matter of hours of work called Samuel Coulson as one witness. This man, who had girls working in the mills, gave this testimony:

Question: At what time in the morning, in the brisk time, did those girls go to the mills?

Answer: In the brisk time, for about six weeks, they have gone at three o'clock in the morning and ended at ten, or nearly half-past, at night.

Question: Had you not great difficulty in awakening your children to this excessive labour?

Answer: Yes, in the early time we had to take them up asleep and shake them, when we got them on the floor, to dress them, before we could get them off to their work; but not so in the common hours.

Question: What was the length of time they could be in bed during those hours;?

Answer. It was near eleven o'clock before we could get them into bed after getting a little victuals, and then at morning my missus used to stop up all night, for fear that we could not get them ready for the time.

Question: Were the children excessively fatigued by this labour?

Answer: Many times; we have cried often when we have given them the little victualling we had to give them; we had to shake them, and they have fallen to sleep with the victuals in their mouths many a time."

Children less than five years of age were at work in the coal mines. Men and women were worked as long as physical endurance permitted. Sanitary arrangements were indecent and everywhere we find cruelty and oppression. Here again we have but sketched the actual condition of affairs.

Labor was helpless and fighting for mere existence. These were the conditions which gave birth to modern labor union-

ism. There is small wonder that the unions have often been violent and unreasoning.

Corrective Influences

Conditions became so bad that they were unendurable. "Labor saving" machinery had actually over-worked some, thrown the rest into idleness, and all into distress.

The wealth of the manufacturers and of the nation as a whole was rising by leaps and bounds but they were holding down the safety valve. The taxes and poor rates increased steadily. There were communities where paupers composed 40 per cent of the population. In the new cities disease spread, mortality rose, riots broke out, discontent and unrest spread everywhere. Illiteracy rose steadily on account of the child labor.

It was clear that the "enlightened self-interest" relied on by economic theorists was breaking down. *Unrestrained* individualism in industry had failed.

In 1796 the Manchester Board of Health made a report which pointed out some of the most glaring evils. In 1802, the first modern Factory Act was passed through the influence of Sir Robert Peel, to give partial protection to the pauper apprentices. It *reduced* the hours of labor for children to 72 per week. They were to be given elementary instruction and one suit of clothes a year. The factories were to be whitewashed annually, ventilated, and the sleeping quarters of sexes separated. A penalty of not more than £5 or less than 40s. was provided. This act raised a howl from the textile manufacturers, but the industry and the country survived.

From 1800 on, Robert Owen showed at the New Lanark mills that good working and living conditions could be maintained with profit and for years his mills stood as a beacon of progress.

A new Act was passed in 1819, raising the age limit to 9 years and limiting the hours to 12 a day. Gradually the paramount right of society to set conditions became accepted. Other acts of 1825, 1833, 1842, 1847, and later ones, have

legally established the conditions of today. The extension of the franchise and the Reform Acts of 1832, 1867, 1876, 1884, 1894, have given the workers a voice in Parliament which they have used to great effect.

These various Acts of Parliament embody the cures which society at large set up to remedy these conditions. Other forces have been at work:

1. *Trade unionism,* at first absolutely prohibited, has given workmen a means of defense. They now have a bargaining power comparable with that of the employers.
2. *A social conscience* has been born, so that conditions once accepted as a matter of course are now universally recognized as morally wrong.
3. *Welfare work.* From 1800 on, Robert Owen at the New Lanark Mills, and later others who have followed him, showed that good working and living conditions were consistent with profits. These leaders were pioneers who first established conditions now accepted by all.

Conditions will never be as bad as they were 100 years ago, and are far better today than they were before the Industrial Revolution set in. Machinery has ultimately enriched and benefited society as a whole, both earner and worker; but the selfishness and brutality of its introduction made the Industrial Revolution in England as tragic, though not as dramatic, as the French Revolution. England has not yet worked free from the rancor and evils which it bred. All this has direct and profound bearing today. The same old forces are at work although under vastly better conditions.

Bearing on Present Mechanical Engineering Practice

It is proper that all three sections of this Summer School be familiar with this record. Whether an engineer is designing a machine, or generating cheaper and more abundant power, or improving the efficiency of the workman, he is trying to raise production and to lower costs. In so doing he is treading the path of the engineers and factory managers 100

years ago, though the change in conditions possible can never be so drastic, if for no better reason than that the workmen today have defenses which they lacked 100 years ago. The same old temptations, however, beset managers and we still hear from "stand pat" executives hot protests against "interference" by the public with their business, which might be echoes from an earlier generation. Any man who contrasts the story which we have reviewed with present-day conditions, realizes that *unrestrained* individualism has run its course. It was tried out and failed.

The machine age has come to stay. Industry must be run on one of three bases, state socialism, the domination of a class, as in Russian Communism, or private ownership and individual initiative regulated and controlled to protect public interest. The United States seems definitely to have chosen the last and the engineer and industrial executive must accept it and work with it, not only under compulsion or law, but with the spirit of cooperation.

I heard recently the Industrial Relations Director of one of our largest rubber companies say that he had learned that their Research Department had succeeded in developing a new machine which would release the labor of about 140 of their most expert workmen. He said, "There's where my job began. When the machine in question had been fully developed and put into operation about a year and a half later, every one of the 140 men had been placed elsewhere in the establishment without disadvantage." This statement was made as a matter of course, without trace of boasting or posing. Contrast this attitude with the spirit of Arkwright who turned his machinery loose without thought of, or care for, its social effects, or the slightest responsibility for what it did to the workmen.

Machinery, power and improved industrial methods, as Dean Kimball has said, "*make possible* a higher state of physical and social well-being, but they by no means insure it. Whether or not these work out as a blessing depends largely on the spirit and manner in which they are introduced."

It is our task to get this across to every mechanical engi-

neer, whether he is designing machinery, producing power, or directing men.

BIBLIOGRAPHY

BEARD, CHARLES. The Industrial Revolution, London, 1901, p. 106.

TOYNBIE, ARNOLD. Lectures on the Industrial Revolution in England, New York, 1884.

FERRIS, GEO. H. The Industrial History of Modern England, New York, 1914.

KIMBALL, D. S. Principles of Industrial Organization, Chapters II, III, New York, 1925.

GIBBINS, H. DEB. Industry in England, N. Y., Scribner, 1925. 10th Edition. Period IV. 16th Century to Eve of Industrial Revolution. Period V. Industrial Revolution and Modern Period.

Industrial History of England. London, Methuen & Co., 1920, 27th edition, p. 241, gives notes on authorities for industrial history.

A RESUMÉ OF MECHANICAL ENGINEERING SINCE JAMES WATT *

By WILLIAM D. ENNIS

Alexander Crombie Humphreys Professor of Economics of Engineering,
Stevens Institute of Technology

Watt was part and parcel of that industrial revolution which is usually tied up with the end of the eighteenth century. There was a concurrent political revolution. James Watt and Thomas Jefferson lived over approximately the same period. The political revolution was founded on a *theory* of government. The industrial revolution was based on specific inventions—the power loom, the spinning jenny, the modern steam engine—with (I believe it is correct to say) little aid from theory. Neither revolution is even yet complete.

James Watt dealt for the first time in a large way with two groups of problems which even today constitute, as I believe, the whole essential subject matter of the orthodox course in what we may strictly call mechanical engineering. These two departments are, first, heat engineering and, second, machine design and construction.

Watt was also closely associated with a third group of problems, of which more will be said presently. Thus three torches have been handed down from his time; two of them from his hand. We will consider the three subjects separately and deal with heat engineering first.

I

The Newcomen engine in 1765 was a commercial machine in about the same sense as the automobile was a commercial

* Presented at the Summer School for Engineering Teachers of the Society for the Promotion of Engineering Education, Purdue University, June 28, 1929.

machine, say in 1903. Watt's great master patents date from the year 1769. He aimed definitely at economy. It is interesting to consider how much he was handicapped by the absence of thermodynamic theory. Ideas on heat engineering were vague. There were those who believed water to be an element. Others regarded air as a sort of superheated steam, fixed by what (as described) would have been a sort of cracking process. Watt himself in one of his letters refers to a claim voiced by a competitor, to have evaporated a hogshead of water from an ounce of coal.

But before Watt's death considerable progress had been made. He made some of it himself. These contributions tie in with three of his principles of design:

(1) He recognized the desirability of a steady temperature of heat reception. It is not clear whether he fully recognized the value of a *high* temperature. True, he used what was high pressure steam for his day, refusing to depend upon vacuum alone to move the piston; but he kept close to the shore line of atmospheric pressure. Watt's engines rarely used pressures above seven pounds gage. Others were more venturesome, but Watt feared and fought high pressure. His engine was like Mr. Ford's Model-T. It was (as he thought) what people needed and he was determined they should have it.

It is of more significance, however, that Watt insisted on a cylinder kept constantly hot. He recognized the disadvantage necessarily inherent, therefore, in small cylinders. The steam jacket, which was Watt's invention also, came later, after he had begun to think of expansive working.

(2) Watt fully realized the value of a low emission temperature. This realization, in fact, led to what was probably his major contribution to the art, namely the separate condenser and air pump.

(3) Watt's line of thermodynamic advance eventually involved the use of steam expansively. This was in 1782. He even concluded that in a simple cylinder, cutoff at about one-quarter stroke was normally desirable.

Watt recognized the limitations of his work resulting from

a lack of fundamental experimental data. He himself studied the total heat of steam (to give it that old-fashioned name), the specific volume and the pressure-temperature relation. A man from the Bureau of Standards or from one of the great college laboratories would be tempted today to regard his results as meager.

The first development in heat engineering following Watt was the compound engine. The early motive for compounding was mechanical rather than thermodynamic. Watt fought the compound. It worried him. Probably he distrusted it on engineering grounds as well as on commercial grounds. It became rather important after 1800, the year of Watt's retirement. There was a long period of competition. In fact, steam engine economy for the better part of a generation was a popular subject for gambling—like the day's run of the transatlantic steamer in our time. The record passed from one competitor to another. There were charges and countercharges, and it became necessary to distinguish between official and unofficial trials. Some of the results claimed for the early Cornish pumping engines are no longer accepted as substantiated. It appears from the record, however, that for the time being, so far as stationary engines were concerned, the high pressure simple engine established its supremacy over the compound.

Eventually, following marine practice, compound and triple expansion engines and even more elaborate forms were developed for pumping; while toward the latter part of the nineteenth century the compound became the standard prime mover in textile mills. Now with the uniflow engine and the turbine, it would seem that multiple expansion was from a long range point of view a "wrong lead"—a "no-thoroughfare," or at best only a temporary thoroughfare or detour. There have been several such no-thoroughfares in mechanical engineering during these 150 years. They are nearly always without a warning sign.

The first great step in the elaboration of thermodynamic theory was the publication by Carnót in 1824, five years after Watt's death, of his "Reflections." Founded partially on

error as his formulation was, it nevertheless stated a truth which no one has appeared to shake.

Naturally, after reaching general agreement that heat is energy, the great work of the heat philosophers, the challenge to experimenters, was the determination of its mechanical equivalent. There were several rough approximations. Then Joule, from 1843 to 1850, arrived at the figure 772 which was generally used until (and even after) Rowland in Baltimore, in 1880, proposed 778.

During the same and a later period the fundamentals of modern thermodynamic theory were gradually built up; mainly by four men, all of them college professors and two of them professors at Glasgow—which must have been a great place in those days.

A first step in building up theoretical fundamentals was, of course, more accurate experimentation. This was furnished chiefly by Regnáult, born 1810. He determined specific heats and worked on the compression of gases (thus distributing to the commercial development of compressed air, which began about 1860). He was a cautious and candid experimentalist of so high a type that his work has even been described as "artistic." Commissioned by the French Government, he conducted a research from 1847 to 1854 on the pressure-temperature relation and the latent heat of vaporization, the results of which have retained their validity until our own times. He worked on other vapors as well as steam; on ammonia, alcohol, ether, chloroform and turpentine, for example; and thus modern refrigeration (on its quantitative side) dates from him. Some of his results were destroyed in the days of the Commune of 1870–'71.

There is even now some uncertainty as to the properties of what may be called "unusual" steam. Research is still going on. A few years back the suggestion was made that the completion of this research was too big a job for any one man or any one institution. Now we have several institutions collaborating in assigned departments of inquiry; and the zone of uncertainty, the circumpolar regions, so to speak, of the steam-field is being gradually narrowed.

We may deal more briefly with the second great name in theoretical thermodynamics—that of Professor Clausius. Clausius restated Carnót's fundamental principle correctly and fully, in the terminology warranted by the mechanical theory of heat. His own textbook bears this very title, "Mechanical Theory of Heat." In it he coined the term "entropy." Americans know the work of Clausius chiefly from Zeuner's presentation in modern form, "The Technical Thermodynamics" so admirably translated by Klein.

The third of these college professors and theorists was William John Macquorn Rankine. He was a profuse compiler of unequally valuable material, at his worst very bad but at his best a powerful contributor to the science. His own statement is, that in 1849 he and Clausius arrived independently at the "general equation of thermodynamics." In his book "The Steam Engine" he states the second law quantitatively: that the work done is proportional to the temperature fall. He also introduces the term "thermodynamic function," which is the same thing as Clausius' "entropy."

A still broader conception (perhaps even an extension) of the second law is due to Kelvin, who announced the principle of the dissipation of energy. Kelvin was born in 1824, the year of Carnót's publication. He was associated with Joule in the latter's experiments. Beyond any question his is the greatest of these four great names; but Kelvin shone in many fields, while the others confined themselves somewhat more narrowly to heat engineering.

Thus the foundations of our subject were well established before 1860. The later work has included experimentation, exposition and reduction to practice. There was some refinement of theory, particularly with respect to heat exchanges in the cylinder. Isherwood in the United States Navy published his "Experimental Researches." Most widely known in this field are Hirn and his associates, who were the professional staff of what seems to have been a cooperative research agency among the textile manufacturers of Alsace, from 1877. Incidentally, Hirn made some study of the properties of superheated steam and introduced engines using superheat in

local manufacturing plants. Superheating in marine practice in both England and the United States dates from about the time of our Civil War. D. K. Clark, who was rather critical of Hirn's pretensions, refers to a 15½ pound steam rate obtained by the latter from a small simple engine using 60 pounds boiler pressure and 150 degrees of superheat. This should have been a warning to the compounds, the best of which were not then claiming steam rates below 14 pounds.

Toward the end of the nineteenth century, after more than one hundred years of supremacy, the steam engine was disturbed by the threat of competition and stimulated by the large power, high economy requirements of the central station. Those concerned with stationary engines were also impressed by the unparalleled performance of the steam locomotive as partially demonstrated in the work begun by Goss here at Purdue.

The forms of competition which began to appear for the stationary steam engine, particularly, included oil engines, which began to be built about 1870. The Otto gas engine in its present form dates from 1876. At about that date it had already developed the unparalleled thermal efficiency of 15 per cent on either gas or light oil. Here we have the forerunner of the automobile and the airplane. The Diesel engine was first proposed in 1893.

Producer gas became a factor in the situation by 1897, when a 400 horsepower unit was announced. By 1910 a gas engine of 5,000 horsepower had been built. There was great enthusiasm and many of us started on another "no thoroughfare." With efficiencies between 30 and 40 per cent, which the steam engine could not hope to obtain, the "dollar economy" of the producer gas plant proved unsatisfactory. The large gas engines of today are those required for operation with natural gas or blast furnace gas. Those engine concerns which engaged in producer gas development are now for the most part building Diesel engines.

Steam power came back strongly; perhaps most strongly in Europe, at first. At the end of the century Germany was in many respects ahead of us in thermal efficiency. There

was a reason for this condition. In Europe, prior to 1914, money was cheap and fuel was dear; with us, money was dear and fuel generally cheap. Thermal efficiency was more important there than here, while dollar efficiency was less important.

Regenerative feed water heating was applied with wide publicity in quadruple pumping engines in 1900. While there were few applications of this idea for some years following, it is now a feature of standard modern practice.

Pressures and superheats, particularly the former, have been steadily increasing, justifying the work recently done by Keenan around the critical point. The curve of steam pressures is almost the curve of steam progress. Watt stopped with five to seven pounds gage. Thirty pounds was high pressure in 1850. The maximum used in 1896 and perhaps until 1900 or so was 250 pounds, with the locomotive leading. Now we have pressures up to 1,700 pounds and within a year or two there will be several large plants using more than 1,200 pounds.

The knockout blow which steam delivered to its competitors was the turbine. Again we bumped into "no thoroughfare:" the vertical shaft, for example. The turbine lends itself to the massing of power as the reciprocating principle can never do. We now have a single turbine unit developing 208,000 kilowatts. Twenty such units would produce as much power as all the horses on all the farms in the United States. The record-breaking Corliss engine of 1876 had two cylinders, 40 inches by 120 inches and developed 1,400 to 2,500 horsepower at 36 revolutions per minute. So spectacular was it that it was started by a president and an emperor. Today we might almost use it as a hot-well pump.

Spectacular as this progress has been, equally important steps have been taken with steam generating apparatus, including combustion devices. This movement got into its full stride as late as 1910. Improved mechanical stokers began it. Then came better furnace design and harder driving. In 1896 we were taught that ten square feet of heating surface were equivalent to a boiler horsepower, and that three pounds

of water per square foot per hour was a fair evaporation rate. Now you may, if you please, rate a boiler on a basis as low as one-half square foot of surface per horsepower, and we may expect a peak-load rate of evaporation of 25 pounds. From 14 to 17 pounds is fairly common. In 1896 a 100 horsepower boiler was a reasonable size. Now there is at Los Angeles a boiler having 35,000 square feet of heating surface. There are, I understand, even larger boilers used in steam heating. Powdered coal was a novelty as late as 1905; but it is not at all a novelty now.

One of the most outstanding recent facts is the growth of the central station as an organism. Capacities have increased. Cheap power is demanded everywhere. More and more industrial use is being made of central station power. Associated with this fact (and perhaps the result of this fact) is a maximum use of power per man in our American factories. In this point we are far ahead of England. There are publicists who argue for cheap domestic electric rates and compare us unfavorably with Canada. They assert that industrial power is sold too cheaply, or at least that the differential between prices of domestic and industrial electricity is too great. I sometimes feel that these men do not really understand the subject. Cheap power is fundamental. It creates economic opportunity. Cheap power is a greater benefit to the wage earner than is cheap electric current in his home.

As late as 1913 a central station coal rate of two to two and one-half pounds per kilowatt hour was thought normal. Now we have figures below one pound; in Boston and Cincinnati, for example. The very high pressure boilers which we are building now are not more costly, but less costly, than old-fashioned boilers—in proportion to their capacity. The cost of construction of steam central stations per kilowatt of capacity has declined rather than increased. Besides these gains in fuel and steam efficiency and in dollar efficiency, there have been broad advances in the art of electrical distribution and in the mobilization of equipment through interconnection and interchange arrangements, so that we now have contin-

uous linkages of power lines extending from Chicago to Boston and south to the Gulf of Mexico.

Paraphrasing only slightly, when we reflect how much of this has taken place within a very few recent years, I may fairly say, "all of this you saw, some of it you were."

We have followed wrong leads, have blundered into no thoroughfares, on several occasions: with the compound principle, again with the gas engine, with some of the earlier turbine developments and of course with the rotary engine, which is always with us. Some of these wrong leads have been due to an over-academic thermodynamics. Progress is now going on with entire harmony of thermodynamic and economic motive and (as in the case of the mercury vapor engine, perhaps) progress in the applications of heat engineering was never more daring than now, and probably never more sound.

II

Our second department in mechanical engineering is machine design and construction. There was not much textbook material in this field readily available to Watt. It was not the habit of the time to regard book learning as having any bearing on shop operations. Some of the books were in Latin. There were very few periodical publications. Applied mechanics was almost unknown. There were incomplete ideas about flexure and concerning columns, but the subjects of shear and torsion had not been developed, and no one was able to determine the stresses in a framed structure. Hooke's law, *ut tensio sic vis,* had been announced.

Whewell, who foresaw that the book and the shop must get together, wrote learned textbooks, bringing the most erudite mechanics down to what he thought a shop level. This influence was partly accountable for the establishment between 1840 and 1845 of six chairs in what may be called applied mechanics at British universities. One of these was to be the seat of Rankine.

A large proportion of the vast number of theorists in this field have been college men: some of them mere recorders, others really creative. Young discovered the modulus of

elasticity. Lampé did early work in the mathematical theory of elasticity. Fourneyron built an outward flow hydraulic turbine in 1826. Poncelet analyzed it and developed a wheel of his own. The first Fourneyron turbine built in the United States dates from 1843. The Francis inward flow American turbine came later and the tangential wheel for high heads was commercially developed in California. The first Niagara turbines were of Swiss manufacture and drove what were then (1898) the largest electric generators in the world—5,000 horsepower.

Along with the philosophers of the subject were two great experimenters, Hodgkinson and Fairbairn. The former was "grub-staked" by the latter. He did work on the strength of materials comparable with that of Regnault in heat engineering. Fairbairn continued this work and studied riveted joints. Other experimenters worked on friction and on the strength of beams and cylinders, in France, England and the United States. Later theoretical advances have been in the analysis of continuous girders, the study of secondary stresses and statically indeterminate stresses, the dynamics of machinery, dynamic balancing, the rational design of rotating discs, the gyroscope and dimensional analysis.

In Watt's day, there were no locomotives, no steamships, no central stations and (comparatively speaking) no factories. There were no means for producing such things, because there were no machine tools. Professor Roe, in his *English and American Tool Builders* says, "The appliances for cutting metal were little better than those of the Middle Ages." In fifty years the firm of Boulton & Watt built 25,945 horsepower of steam engines. We may guess that this was perhaps half the world's output. At this rate it would take about 40,000 years to replace the prime movers existing in the modern power plants.

Watt was a precision worker, a model maker; but model making is very different from determined accuracy on a commercial scale. The only shop practice of Watt's day which we could possibly call good was in forging. Watt's cylinders required better workmanship than those of Newcomen engines

and Smeaton was pessimistic about the value of Watt's invention, because, as he thought, it would never be possible to carry on shop operations with the degree of precision which Watt's engines required.

There was a rudimentary horizontal boring mill which would bore an 8-inch engine cylinder with a three-eighth inch variation in diameter. Wilkinson, by adding an outboard support to this machine, created the first modern machine tool. Roe says it was "probably the first metal working tool capable of doing large heavy work with anything like present-day accuracy." Boulton reported that cylinder bores from this machine were accurate "within the thickness of a worn shilling."

The lathe reached approximately modern form between 1800 and 1820. The planer was developed between 1800 and 1830. Originally it was without the quick return and it cut in each direction. The shaper came along in 1836. The American turret lathe was brought out in 1854. This country produced automatic lathes for metal shortly after 1880.

A type of miller was used in France for fluting taps before 1800. The English used an index miller for hex nuts. Our own country, which developed the universal miller, had its first experience with this tool in the cutting of grooves in twist drills.

Punching and shearing machinery, the steam hammer and improved taps and dies were all available in England by 1840. Early English development culminated with Whitworth, who at the London Exposition of 1851 displayed what were called "the finest tools in the world." His screw thread standards were adopted for general use in Great Britain by 1860.

Now let us turn to early American history. The colonies for a time suffered from stupid legislation; but about 1750 the parliamentary policy was modified so as to encourage the production of American iron. Iron mines were opened in Orange County, N. Y. At least one of these is still in operation. There was also much early iron smelting in New England; and just before the Revolution, in northern New Jersey.

The steam engine and the steam locomotive, both, in this

country owe something to the rather remarkable character, Oliver Evans. In correspondence with Evans on both subjects was John Stevens, a great projector if there ever was one, using the term in an entirely complimentary sense.* Stevens was designing engines by 1789, and secured patents—among the first ever issued by our government—in 1791.

The locomotive cannot with any appropriateness be linked up with any one man or any particular date. The steam automobile came first. The first steam locomotive running on rails seems to date from 1812. Stevens in 1825 ran the first locomotive ever operated on rails in the United States.

There is vague testimony that the exhaust nozzle had been used on a locomotive by Trevithick. It was reintroduced and applied by Stephenson before 1825 and it may have been responsible for the winning in 1829 of the celebrated prize offered that year, by Stephenson's Rocket. It should be remembered that John Ericsson was one of the competitors for this prize, and that his locomotive received the second award.

During the past 25 years there have been only three important builders of locomotives in this country. The three of them operated about 14 plants in 1905, but there are only about six or eight locomotive building plants in actual operation today. Locomotive design has developed so rapidly and locomotive operation has improved so radically that the builders of this country find themselves overequipped. For years they have been doing their utmost to turn out improved machines, one of which would replace two old locomotives and would haul heavier trains at higher speeds. Simultaneously, railroad managers have been lengthening the working day of the steam locomotive, and have been quadrupling and quintupling the working day's mileage.

We seem to have passed the period of highest railroad speed. One could have moved between New York and Chicago by rail in less time 25 years ago than today. Railroads have progressed in other directions, and particularly in the cheap and dependable movement of freight. Not stopping to stress the air brake and modern signaling equipment, there were

* *John Stevens, An American Record*, by A. D. Turnbull.

the articulated engine introduced by Mallét in France in 1876 and applied in this country in units of colossal size, the experimental development of water tube locomotive boilers using up to 850 pounds pressure and more, and that most modern thing, the booster, which gives us additional cylinders, driving wheels and tractive force when we need them.

The idea of steamboating was incipient by 1698, and there was an English patent covering the application of a Newcomen engine to marine transport in 1736. An iron steamboat was propelled on a Scottish loch by Symington in 1788. Toward the close of the eighteenth century Rumsey and Fitch in the United States were approaching commercial application, and the latter of these men ran a steamboat on the Delaware.

It was John Stevens, according to Rankine, who applied the screw propeller to a ferryboat on the Hudson River in 1804. Stevens' vessel, the Phoenix, made the first trip to sea ever made by a steam vessel, in 1809, from New York to Philadelphia. Robert Fulton had commercialized steamboating on the Hudson River with his Clermont in 1807.

William Fairbairn, built the first large shipyard in Great Britain and accelerated the building of iron ships. A dramatic step, around the middle of the nineteenth century, was that by which John Ericsson placed the United States "at the forefront in naval power" by his ironclad, the famous Monitor. The Monitor, while it rendered useful service at a critical time, proved ultimately to be a "no thoroughfare" of design. The revolving turret principle is retained in modern fighting ships, but the low freeboard was abandoned many years ago.

Boilers long lagged behind heat engine development. Late in the nineteenth century, in this country, clever designers, chiefly in New England, carried the fire tube stationary boiler —our familiar horizontal return tubular type—to an advanced point: building it for high pressure (as it was then called) and occasionally in large capacities. During the same period modern boiler shop equipment began to include hydraulic riveters and flanging presses. The water tube boiler has been the invariable type in important stationary practice only during the last 25 years.

Evaporating apparatus for producing fresh water at sea and for use in sugar manufacturing and wood pulp making were comparatively early improvements, while the general subject of efficient engineering in process steam has made its advances chiefly within the last two decades.

A dramatic story is that of Whitney and the cotton gin, which he invented in 1792. It is due chiefly to Whitney that cotton cloth is now a staple merchandise in almost every part of the world and serves as actual currency in some parts. Whitney observed that it required a whole day's labor to gin one pound of cotton. When he applied for his patent, the total export of raw cotton from the United States was less than 10,000 bales annually. In 1925 it was over 8,000,000 bales, and total production in this country was about 18,000,000 bales. The cotton gin committed the South to agriculture and slavery. It caused the rise of New England in manufactures. By 1815, according to Roe, there were 140 cotton mills within thirty miles of Providence.

Not only New England, but old England, was industrialized by Whitney's invention. The early English "millwrights" worked in or for textile mills. Cotton spinning produced a great market for steam engines and for textile mill machinery directly; and indirectly for machine tools with which to build spinning frames and looms. The first machine shops in New England were built as auxiliaries to the textile mills.

It is interesting at this point to trace the growth of certain of our manufacturing towns. One of the earliest was Paterson. Here under the auspices of Alexander Hamilton, the Boudinots and others founded the Society for Useful Manufactures, a water power development organization which still exists.

The hydraulic development at Lowell began in 1825. The City of Pawtucket was similarly developed on the basis of a local water power, but the growing importance of steam soon gave the neighboring City of Providence, without water power, a distinct leadership. The Amoskeag Mills and the City of Manchester were founded in 1822. The Ansonia Brass and

Copper Company and the brass and copper working of the Naugatuck Valley date from 1836.

A record of this sort is not complete without mention of some others of the well known firms still existing, the beginnings of which date back into a venerable past: firms like the Gorham Manufacturing Company, the Builders Iron Foundry of Providence, Washburn & Moen, Baldwin Locomotive, Gould & Eberhart, Russell & Erwin, R. Hoe & Co., Yale & Towne, etc. These firms average about a century old.

The McCormick reaper was invented in 1831 and improved in 1845. It was estimated in 1859 that its value to the United States was $55,000,000 yearly and it was then credited with being the primary cause of the westward movement of our frontier at the rate of 30 miles per year. Thus, like the cotton gin, it was one of the indirect accelerators of our Civil War.

Goodyear vulcanized rubber about 1837 and further improved the process in 1839.

As pointed out by Roe, the early important stimulus for all of our machine tool improvement was gun making. Foremost in this field was Eli Whitney, who entered it after his disappointing financial experience with the cotton gin. It made money for him; and it is interesting to record that his ultimate successor in the firearms business is the Winchester Repeating Arms Company. Another early gun maker (more properly a pistol maker) was Simeon North, who began operations in 1808. The present-day Remington and Savage concerns trace their descent from North.

It was in 1842 at the Springfield Armory that the first important use was made of jigs, approaching modern practice in form and application. These were employed in the manufacture of muskets. The *Colt* Armory, a private establishment, has been referred to as the greatest training school for machine designers that this country has seen.

In the broader fields of machine construction and application there is a complicated progress to trace. Much of the progress we owe essentially to two great firms: Sellers of Philadelphia and Brown & Sharpe of Providence, the latter in its inception having a connecting link with Pratt and Whitney.

Brown & Sharpe have made precision measuring tools a part of every machinist's kit. They standardized the American wire gauge in 1857. They introduced a gear-tooth milling cutter which retained its form when reground, in 1864. We owe chiefly to Brown & Sharpe the development in this country of cheap interchangeable gearing. The Providence firm introduced the use of limit gauges in the early sixties, and their shop has been a great breeder of widely known machine tool designers.

The beginnings of the Sellers firm were in 1848. (The Bement organization started in Philadelphia at about the same time.) Sellers introduced the United States standard screw thread in 1864, a standard which has been adopted for much of continental Europe.

Great family trees of tool builders started in Worcester and other New England towns. Cincinnati, Cleveland and Hamilton, in Ohio, engaged in machine tool building, with other western cities, from around 1880. The first named of these cities is said to be now the largest tool building center in the world.

The pneumatic tool has been a feature of the progress of the last generation—the modern riveting hammer dating only from 1898. Probably the variety and magnitude of applications of compressed air in general shop operations has also increased most notably during the last 30 years. The same period has seen the development of molding machines, of forging machinery and of die castings.

About 1900, the use of high speed steels, with much heavier speeds, feeds and cuts than had been customary, began to break down our machine tools, and there followed a period of redesign, since which time tools have been heavier. We could not have fought the World War as we did if it had not been for the stronger metal cutting tools which we had been building for 15 years, largely under the influence of the automobile factories.

In the very recent past we have had the cellulose industries, starting, perhaps, with wood pulp and leading to rayon as the most spectacular recent incident.

Yankee ingenuity has not been satisfied to remain on the factory side of the big gate, but has entered the business office with typewriters, comptometers, tabulators and a myriad of alleged or actual labor-saving machines.

Today everyone is talking about the future of aviation—from which it is difficult to dissociate the name of Lindbergh.

Momentous though relatively intangible, in all of these expansions, was the development of improved communication. In 1842 Congress, after urging, decided to take a hand in promoting the Morse telegraph; but it was remarked that the device was "interesting, but of no importance either scientifically or commercially."

The telephone was reduced to practice in 1877 and Alexander Graham Bell lived to be richly rewarded. I dare say nothing about the radio.

The average annual output of coal in the United States from 1821 to 1830, 60 years after Watt's invention, was 140,000 tons. In 1926 it was 658,000,000 tons.

What seems to me to be one of the most significant of all of the lines of development is that which has been apparent in domestic engineering: the bringing of the skill of the engineer to bear on the operation of the household.

The average family in George Washington's time, in order to have food, was obliged to run a farm or at least a transport line. It did some of its own slaughtering; and the preparation of food for either use or storage consumed a great deal of time. We now have manufactured ice and mechanical household refrigeration. Our meats are slaughtered in Chicago or Omaha. We buy better canned goods and better preserves than our wives ever made.

As lately as 1917, we found that the women had not entirely forgotten how to knit. Once they had to spin and weave as well. These things have been quite completely forgotten. The sewing machine was brought into being by Elias Howe only in 1846. Mechanical engineering has helped in the matters of food and clothing.

Without referring to new materials, new features of workmanship, skeleton steel construction and so on almost *ad*

infinitum, let us mention some of those things related to *shelter* which we take for granted: modern central heating, for example, still uncommon in other countries: positive ventilation in some of our larger buildings: city water and sewers. And perhaps worth as much as all of these are improved methods of lighting.

Thus engineering has contributed to give us advantages and conveniences in food, clothing and shelter which George Washington, perhaps the richest man of his time in this land, could not have enjoyed at any price. Engineering has done more than this: it has contributed to higher needs than those elementary physical needs which I have mentioned. It has brought about an economic standard at which comparatively poor people may secure (although with some difficulty) the services of the doctor and dentist for their children. The average boy of to-day may look forward to a better education than George Washington's step-son could have obtained. To-day's average boy is required by law to remain in school up to a later age than did George Washington himself.

One of the most impressive things about this century and a half of engineering is that it has decreased the amount of direct servile labor in the world. George Washington had to have dozens of people to wait on him. His comfort demanded it. Those of lesser means suffered from the lack of such services. To-day we all receive most of them from great impersonal organizations or syntheses and are scarcely conscious of human agencies. Thus there is no longer the distinct class of gentry, on the one hand, and the equally distinct class of dependents on the other. Caste has become impossible. Workmen are no longer servants. They are men doing business with you.

These are the answers to the assertion sometimes made that machinery is brutalizing mankind. Machinery does not enslave men, it sets them free. It is the greatest liberating force that the world has ever known. It is machinery which enables man to make the best and highest use of his opportunities.

III

Having thus sketched the progress made in the two fields of heat engineering and machine design and construction, I now propose (perhaps whimsically) a third topic in this resumé, a subject which began with Watt, although not started *by* Watt.

The early economists coined a new name for the industrial manager; introducing a term which (freely translated) means "enterpriser." Watt's senior partner, Matthew Boulton, was the typical enterpriser,—a man who may easily have been in mind when some of the contemporary writers on political economy were describing management. Boulton and Watt were partners for over twenty-five years.

It seems appropriate, therefore, to present a brief review of the history of what some will call *industrial engineering*.

My fundamental thought is that advanced management, scientific industrial engineering, did not begin around 1890 or 1900, or 1910 or 1920, as some engineers would variously put it, but far earlier; that the things which we are so proud of doing today had their antecedents in or around the time of Matthew Boulton just as truly as today's central station had its antecedent in the inventions of James Watt.

Boulton was a notable man, whose name and fame are somewhat overshadowed by Watt's. He was a forerunner of modernism. He had the personal qualities of leadership. Like nearly all successful managers of affairs, he was of the objective type. Watt wrote of him some time prior to 1773, and before the partnership commenced, as "an ingenious, honest and rich man." . . . "The worst I ever heard of him" (says Watt) "amounted to his being a projector." Contemporary records from other sources say of Boulton that he "dignified the name of a British manufacturer."

Boulton had the right background. His career reads like that of an American boy more than a century later. Although his father became moderately rich before his death, Matthew was largely self-educated. He seems to have enjoyed his father's confidence, and was given responsible work to do;

work which he did well. When he inherited the Birmingham factory he might easily have retired to live the life of a country squire; but he preferred business to leisure. The Boulton plant at Birmingham was internationally famous; was one of Great Britain's show places; was visited by royalty; and before Watt ever saw it, employed a thousand men. This made Boulton one of the greatest business men of his day. He occupied a position in the public mind somewhat like that held by Henry Ford in our time.

Boulton was a good organization man. He was strong at team work. His entire relationship with Watt is a pleasing picture. The latter wrote in his old age "Our friendship continued undiminished to the close of his life . . . to his friendly encouragement, to his partiality for scientific improvements, and his ready application of them to the processes of art; to his intimate knowledge of business and manufactures, and to his extended views and liberal spirit of enterprise, must in great measure be ascribed whatever success may have attended my exertions."

Today you may find the graves of these two men together at Handsworth Church. In death they are not divided.

Watt first visited the Birmingham plant by invitation in 1767, and he and Boulton met the following year. The two men took plenty of time to get acquainted. Boulton wished to enter into a partnership, but postponed action until he could be sure of meeting the financial obligation involved. Possibly he wanted also to be certain of the patent extension. Watt's equipment, materials and work in process were finally shipped to Birmingham, and Watt moved there in 1775. There his headquarters were throughout the period of the partnership.

Both of these men were *square*. On one occasion, when obstacles arose to the contemplated partnership, Boulton wrote to Watt: "I was excited by two motives to offer you my assistance—which were, love of you, and love of a money-getting ingenious project." He had, he says, "an idea that you wanted a midwife to ease you of your burden, and to introduce your brat into the world." Boulton continued, "I live in

hopes that you or I may hit upon some scheme or other that may associate us."

Neither of these men was over-optimistic. Watt wrote, sometime before 1773, "the success of the engine is yet far from verified." Boulton in 1774 called it a "shadow."

Boulton was parexcellence a shop manager. He knew how to stimulate human productiveness, to train men, to bring about specialization. Watt had complained of "the difficulty and expense . . . of procuring accurate and honest workmen, and of providing them with proper utensils, and getting a proper overseer or overseers." This was henceforth Boulton's job.

In every respect Boulton exhibits a modern attitude; as in his general economic faith; and as in his feeling toward apprenticeship; an attitude more modern, in fact, than that of many managers in England today. He refused to take on what were called "gentlemen apprentices." with a premium. "I," he said, "am training plain country lads into good workmen; and wherever I find indications to skill and ability, I encourage them." Possibly Boulton practiced, if he did not introduce, the furnishing of incentives to gang bosses and department heads, which we think of as something invented only yesterday. Yet John Stuart Mill stated of such men, "It is a common enough practice to connect their pecuniary interest with the interest of their employers by giving them part of their remuneration in the form of a percentage on profits." All that we did in this matter in our twentieth century shops was to reinvent something which was fairly common more than a hundred years.

Boulton also developed specialization. There was great difficulty in making parts that would fit. "They met this by confining each workman to a particular task in which he became so expert that he was able to turn out parts which were similar if not identical."

Boulton handled large affairs with poise and with a complete absence of irritability or of any grasping attitude. This is well exhibited by the simple contract between him and Watt. Boulton was to do all necessary financing, no limit

being set, and to receive two-thirds of the profits from the patents. The cost charged was to include all prior and future development expense. Watt was to be the designer and to be paid his out-of-pocket expenses when away from headquarters. Boulton was to manage the works, accounting and sales. Apparently neither was to draw any salary. The partnership was for the definite term of 25 years, so as to terminate with the expiration of the extended patents. In 1776, very early in the firm's history, on the occasion of Watt's marriage, Boulton upon request valued his (Watt's) interest in the business at from 2,000 to 3,000 pounds; adding, "but I should be sorry to make you so bad a bargain . . . hoping we shall harmoniously live to wear out the 25 years, which I had rather do than gain a Nabob's fortune by being the sole proprietor." Two years before, the engine had been a "shadow." Now it was to yield a Nabob's fortune; and it did.

Boulton was a phenomenal business and sales manager. Cornwall constituted a real exigency. Following hard times, the mines were flooded. Their production had come to a standstill. Mine relief in Cornwall around 1780 was an issue much like farm relief in the United States in 1929. Cornwall was the market for Boulton and Watt. The high efficiency of their engines made it possible to pump out these old mines on an economic basis. Thereafter the firm constantly maintained a residence at Cosgarne, which was alternately occupied by the Boulton and Watt families. One remarks that Mrs. Boulton and Mrs. Watt must have been unusually amiable people also.

Boulton introduced a profit-sharing sales plan. From the very first the price of the engine was based on its performance. Some early contracts stipulated that the manufacturers of the engine should receive one third of the value of the fuel saved—as compared with the original Newcomen engines. This, of course, made the burden of financing on Boulton considerably greater than it would otherwise have been, and this burden continued under a later and somewhat similar arrangement.

Other features of Boulton's sales policy may be mentioned. The firm became active in the conversion of old Newcomen engines. Boulton said that repair work of this sort was a "better trade than new erections, and that work alone will be sufficient for our lives." It is not so very long ago that the writer was engaged in a business where it was a fundamental maxim that contracts carried the overhead but that the profit came from jobbing: not so very different from the Boulton & Watt condition.

Boulton ran his business according to schedule. Around 1775, in the initial period, that schedule called for 12 to 15 "reciprocating" and 50 "rotative" engines per year.

Boulton safeguarded his business. There was a long period of patent litigation; on so large a scale that the partners paid one solicitor's bill of nearly 5,000 pounds.

The partners built up a permanent organization. Watt was fortunate in his staff as well as in his partner. Two names stand out especially: those of John Rennie, one of a great family of engineers, and of "the incorruptible" Murdoch. (The latter, incidentally, developed the art of lighting by coal gas.)

Boulton met the final test of material success, and he met it by letting other men make some of the money. Watt became comfortably rich. The partnership profits had reached 3,000 younds yearly as early as 1782. At the time of Watt's retirement the sons of Boulton and Watt had long been active in the management of the business. As they carried it on after 1800, it continued to be highly profitable for nearly 40 years. "Why not?" says Jeffrey, "It is our improved steam engine that has fought the battles of Europe, and exalted and sustained, through the late tremendous contests (Napoleonic wars) the political greatness of our land. It is the same great power which now enables us to pay the interest of our debt and to maintain the arduous struggle in which we are still engaged."

The art of management was thus fairly under way before the year 1800. I have treated that early period at length because its importance is not always appreciated. There were

other early exponents of management. There was Bentham, for example, the brother of Jeremy and developer of woodworking machinery, called by Roe one of the first and greatest of efficiency experts. There was Maudslay, who introduced that simple but basic thing, the surface plate, and who developed a bench micrometer that would read to the thousandth of an inch. He was a great procreator of engineering progeny, a trainer of men; and very distinctly what some would call today an efficiency engineer. He and Bramah developed at Portsmouth the interchangeable manufacture of pulley blocks for naval vessels. Thousands of these blocks were used on a single ship.

Even the old economists knew something about the specialization of labor, and the men just mentioned and others were practicing specialization. Writing as early as 1776 about watchmaking, Mill mentioned, quoting from Babbage, that "the watch-finisher . . . is the only one out of 102 persons, who can work in any other department than his own."

Neither is interchangeability a new thing. Thomas Jefferson, writing from France in 1785, speaks of the interchangeable manufacture of parts of muskets, giving credit to one Le Blanc. There were plenty of early approximations to interchangeable manufacture in England around 1800. Bodmer was one of the practitioners. Of course the standard was not up to the present level, since there were no limit gauges. Eli Whitney developed the art in the United States in firearms manufacture, and its results became spectacular when this country shipped to England the machinery for manufacturing the Enfield rifle. It was then regularly described abroad as the "American system." and when we consider the world's automobile production of today, it is still largely an American system.

Distinctly American contributions to management resulted from our wealth of raw materials, and from our scarce and high cost labor. This country has been the leader in standardization and in applications of machinery to save labor.

Of course we must say something about F. W. Taylor. It

is difficult to hold down a discussion of Taylor's management principles to reasonable bulk. It may perhaps be suggested that two outstanding things in his doctrine are, (*a*) the providing of a fair incentive to the worker, with a whole volume of emphasis and elucidation warranted in connection with that word "fair"; and (*b*) detailed planning for indirect production; a thorough study of the best way to do a thing by someone who is not going to do it.

Thus in hasty review we come to the World War. Catastrophic as it was, it has its bright side, its silver lining. In ascending order I mention three benefits which have come to us from the war:

(1) A widely diffused investment surplus, which is slowly making this country more enterprising and more industrially minded;
(2) Greater industrial effectiveness;
(3) Advances in public health work.

We have learned, in spite of many errors and wastes of colossal magnitude during the war period, that it is possible to have simultaneously, high production, high wages, low costs, and, as we now think, low prices. The last objective has not been fully realized, largely because our greater industrial effectiveness has not yet been carried into the department of distribution.

The war taught two lessons in manufacturing. It taught the managers the wisdom of paying good wages, and the workers not to fear that the supply of jobs would be insufficient. With the war, the philosophy of restricted production, that destructive "birth control" of economics, ceased to be a practical philosophy in American workshops. We all realize, of course, that with increased man-hour production, grave temporary problems of readjustment arise. Perhaps we shall survive or perish according to the intelligence, equity and goodwill we apply to the solution of those problems.

Let us look ahead. People are talking about, and in a small way practicing, the five-day week. Those of us who believe in our economics have always argued that the world need never

worry about having jobs enough to go around. We are in the world to get food, raiment and shelter by producing them. If we produce magnificently then we either get more of them or we have more time to go fishing. In the last 30 years we have created infinitely more of them for ourselves. We are are entitled (if we like) to take more time for fishing. Thus the five-day week is really a test and verification of industrial efficiency. I believe it is coming. I doubt whether its starting in the building trades is altogether the logical first step.

Among all nations we have the money for progress. We are using the most mechanical power, and may well do so, since expenditures for fuel and purchased power in our factories are only three per cent of the value of product realized. According to an estimate by Orrok, the world's equipment of mechanical power aggregates 1,700,000,000 horsepower, of which 1,000,000,000 are in the United States. We have about eight horsepower per capita: the rest of the world, about four-tenths of one horsepower. Taking a horsepower as equal to six manpower each average human being in this country has nearly fifty slaves to serve him. The unskilled laborer, paying top prices for electricity, may own the equivalent of one slave, at a cost equal to only five per cent of his earnings.

We are developing higher human efficiency. Our people need not be, or remain, hewers of wood and drawers of water, for they are learning how to tame all the powers of nature in their service. In eighty years past, while our population has increased over five times, the number of workers in our factories has increased about nine times, the volume of factory production about thirty times and its money value about sixty times. What is still more significant, annual earnings of the average factory worker have increased over five times, while the percentage of product value expended for wages has decreased from 23.3 to 17.3. It is a sufficiently modest statement to say that these magnitudes of economic progress could not have been realized had it not been for the contributions of mechanical engineering.

MINUTES OF THE COUNCIL MEETINGS, JUNE 18 AND 21, 1929

Present: D. S. Kimball, President; G. C. Anthony, F. L. Bishop, G. M. Braune, J. M. Bryant, Paul Cloke, C. S. Coler, R. C. Disque, S. B. Earle, S. S. Edmands, T. M. Focke, A. M. Greene, Jr., H. P. Hammond, Sada A. Harbarger, W. K. Hatt, D. C. Jackson, M. S. Ketchum, O. M. Leland, C. M. McKergow, Wm. T. Magruder, G. B. Pegram, A. A. Potter, H. S. Rogers, R. L. Sackett, R. A. Seaton, Chas. F. Scott, A. N. Talbot, F. E. Turneaure, C. C. Williams, W. O. Wiley, S. M. Woodward. (31.)

1. Professor Scott, Chairman of the Board of Investigation and Coordination, made a report of the activities of that Board. The Council moved a vote of confidence in the Board and the continuation of it.

2. It is the sense of the Council that the Society looks favorably upon joining with the American Engineering Council, if suitable arrangements can be made.

3. The question of this Society classifying engineering colleges was laid upon the table.

4. The question of whether or not to continued publishing the Proceedings was referred to the Executive Committee with power to act.

5. The Summer Schools. Mr. Hammond, Director of the Summer Schools for the Society, reported the gift of $10,000 to the Society from the Carnegie Corporation for the overhead of the summer schools for three years. The council approved the action of the Board of Investigation and Coordination in selecting civil engineering as the topic for the 1930 summer school and Yale University for the site. Mr. Hammond reported $2,500.00 secured through Dean Warren for the support of this session.

An invitation was received from the Carnegie Institute of Technology to hold a session on drawing at that institution in 1930. Motion that at the discretion of the Board and con-

tingent upon making suitable arrangements and securing the necessary funds that a session on drawing in 1930 at Carnegie Institute of Technology meets with the approval of the Board. Carried.

6. The Executive Committee presented the following budget for 1929–30 which was approved:

Receipts:		
Individual dues		$ 8,000.00
Institutional dues		1,770.00
Back dues		500.00
Advertising		2,000.00
Sale of publications		350.00
Estimated receipts		$12,620.00
Disbursements:		
A. 1930 Meeting	$ 400.00	
B. Journal, Proceedings, Year Book	6,000.00	
C. Committee Expenses	150.00	
D. Secretary's honorarium	1,000.00	
E. Clerical Assistance	3,000.00	
F. Sundry Printing	300.00	
G. Postage	300.00	
H. Telephone and Telegraph	50.00	
I. Supplies	50.00	
J. Traveling Expenses	500.00	11,750.00
Estimated Surplus		$ 870.00

7. Dean C. C. Williams, Chairman of the Institutional Division, presented the following report which was accepted.

Uncertainty of Procedure.—Without attempting to offer an excuse for shortcomings in achievement during the year I should like to mention two matters which tend to lessen the effectiveness of the work of the Division in the interim between conventions.

"In the first place, lack of definition of the status of the Division renders its procedure uncertain. In general, the deans and presidents of institutions constitute the membership of the Division and technically any committees appointed should be from this membership. Such a procedure sometimes makes it impossible to secure men on committees who have the time and interest to conduct a study of an assigned problem.

"Uncertainty as to the order of procedure also in the appointment of committees, expenditure of funds allocated and method of undertaking work assigned all tend to lessen the effectiveness of the Division.

"*Organization.*—The Institutional Division is hampered somewhat in its operations by a lack of organization. An attempt was made this year to remedy this defect by asking the institutions to make their appointments of representatives early in the year in order that the sentiment of the Division might be ascertained on occasion and that the representatives might be kept informed concerning special projects undertaken by the Division. While this action was helpful and should be continued, still the organization is too unwieldly to be effective.

"If the Council should authorize and the Division should see fit to provide an executive committee of about five or seven members such a committee would render the operations of the Division more effective in the interim between conventions. Such an executive committee might be made up from the Council in such a way as to avoid multiplying offices and at the same time place the committee in close contact with the officers of the Society itself.

"*Activities During the Year.*—The Division undertook the program recommended by the Board of Investigation and Coordination concerning the two projects, namely, (1) The coordination of preparatory and engineering education and (2) personnel problems. The Board appropriated $1,000 for incidental expenses. The Committees so far have not drawn heavily on this fund.

"A committee was appointed on the former project to summarize the present knowledge concerning the predictive value of various indices of probable success in an engineering course, such as high school grades in all subjects, high school grades in mathematics and physics, aptitude and placement tests and entrance examinations. It was felt that this study was fundamental to any program of coordination of preparatory and engineering education. An index that will enable the prospective student to answer his own question as to whether or not he has the ability and the natural inclination suitable for an engineering course is desirable. The committee with Dean T. M. Focke as chairman has been studying this matter and it is hoped that the material to be presented by this committee will be of value in this connection.

"Two committees on personnel problems were appointed and have been actively at work, one on Industrial Aptitudes

of Technical Graduates, with Dean A. M. Greene as chairman, and the other on Personnel Instruction with Dean R. L. Sackett as chairman. The assignment of these two committees contemplates the two aspects of the problem of student personnel, namely, first, the discovery of latent or embryonic industrial aptitude, and second, the development of managerial ability. These two committees are composed of representatives both from engineering schools and from industries and their reports will contain information of value.

"*Cooperation with Non-Collegiate Technical Schools.*—Some consideration was given to calling two or three joint meetings of the representatives of the Division with representatives from a few typical trade schools and some of the larger high schools with a view to devising a plan of coordinating sub-collegiate work with regular engineering courses. After an exchange of letters on the subject among the officers of the Society, it was decided that the limitations of the program at the annual meeting would not permit an adequate discussion of the results of any such enterprise and the matter was postponed to a future time.

"Apparently no action has been taken on the proposal made in 1927 to appoint a committee to consider extending institutional membership to non-collegiate technical and trade schools and to certain high schools. Such institutions might be accorded associate and junior institutional membership including floor privileges but not a vote, or a special division for such might be created. The Constitution admits anyone to membership who is interested in engineering education, hence, the representatives from such institutions are eligible to membership, as the present roster testifies.

"It is proposed to bring the matter before the Division meeting for consideration looking to the appointment of such a committee."

8. Mr. L. W. Wallace, Secretary of the American Engineering Council, was elected as the third member representing the Society on the American Council on Education. The other members are H. J. Hughes and F. L. Bishop.

9. Invitations to hold the 1930 meeting were received from Lafayette College, Lehigh University, University of Missouri, Syracuse University, McGill University and the Ecole Polytechnique. Upon motion the invitation of McGill University and the Ecole Polytechnique to hold the meeting in Montreal was accepted.

10. The Secretary was instructed to write to Professor F. W. Roys asking him to make, without cost to the Society, a plan to produce a series of motion or still pictures which would display the field of activity of the various groups of engineering.

11. No report from the Policy Committee.

12. All applications for institutional membership were referred to the Executive Committee with power to act.

13. The Executive Committee was requested to start the formation of a WHO'S WHO IN THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION, thus securing professional records of members.

14. Council approved the petition of the New York–New Jersey Section of the Society to change its boundaries to include "Engineering institutions and members of the S. P. E. E. in the State of Pennsylvania within twenty-five miles of its eastern boundary and in the State of Delaware." Council also approved changing the name to "The Middle Atlantic Section."

15. Changing the style of the year book was referred to the Publication Committee with power to act. It was the sense of the Council that this book should be printed early in the year, preferably in November, also that the geographical list be arranged according to institutions rather than home addresses.

16. Council approved the employment of one court stenographer for the annual meetings.

17. The American Society of Mechanical Engineers will celebrate its fiftieth anniversary in April, 1930. This Society was invited to appoint two official delegates to assist the A. S. M. E. in the observance of the occasion. Council accepted this invitation and the President was authorized to appoint two delegates and two alternates. (President Kimball appointed General R. I. Rees and Professor W. S. Rodman as delegates and Dean Harold Pender and Dean J. R. Lapham as alternates.)

18. An invitation from Purdue University to hold the 1931 meeting at that institution was received. The Council ex-

pressed its appreciation of this invitation and referred it to the next meeting of the Council.

19. An invitation was extended to each Council member to attend the sessions of the summer school on mechanical engineering held at Purdue University, June 25 to July 18, 1929.

20. To meet the demands of the members, the Council instructed the Secretary to give as wide publicity as possible within our funds to the address delivered by President D. S. Kimball, "The Economic and Social Significance of Engineering Education."

21. The Secretary was instructed to ask the secretaries of the founder engineering societies to aid various institutions to secure photographs of prominent engineers to hang upon their walls. It is believed that these photographs together with biographies would he inspirational to the students.

22. The Council instructed the Assistant Secretary to send flowers to Mrs. Wm. T. Magruder and to express to her its regrets that she was unable to participate in the meeting of the Society.

23. It was the sense of the Council that a division dealing with cooperative colleges be established by the Society and that the cooperation of the Association of Cooperative Colleges be asked in forming such a division.

24. The following applicants were elected to membership:

ABELL, ASHEL C., Associate Professor, State College of Washington, Pullman, Wash. H. V. Carpenter, F. W. Welch.

AHLQUIST, ROBERT W., Instructor in Electrical Engineering, University of Pittsburgh, Pittsburgh, Pa. H. E. Dyche, Nell McKenry.

BARNETT, BRINKLEY, Assistant Professor of Electrical Engineering, University of Kentucky, Lexington, Ky. W. E. Freeman, E. A. Bureau.

BOGGS, ROBERT W., Mechanical Engineer, Union Carbide Company, 205 East 42nd St., New York City. W. R. Cornell, H. S. Rogers.

CARRUTHERS, JOHN L., Assistant Professor of Ceramic Engineering, The Ohio State University, Columbus, Ohio. A. S. Watts, E. A. Hitchcock.

COBLEIGH, WILLIAM M., Dean, College of Engineering, Montana State College, Bozeman, Mont. L. D. Conkling, O. M. Leland.

COOPER, CHARLES D., Instructor in Engineering Drawing, The Ohio State University, Columbus, Ohio. T. E. French, W. T. Magruder.

DATES HENRY B., Professor of Electrical Engineering, Case School of Applied Science, Cleveland, Ohio. C. S. Howe, T. M. Focke.

FAIRBANKS, OSCAR W., Assistant Professor of Drawing and Design, Michigan State College, East Lansing, Mich. R. K. Steward, E. H. Stewart.

FOURAKER, RAYMOND S., Associate Professor of Electrical Engineering, North Carolina State College, Raleigh, N. C. Wm. Hande Browne, Robert R. Brown.

FRAZIER, FORREST F., Professor of Civil Engineering, Kansas State Agricultural College, Manhattan, Kans. R. A. Seaton, L. E. Conrad.

GILL, JAMES H., Professor of Machine Construction, Superintendent, Engineering Shops, West Virginia University, Morgantown, W. Va. C. R. Jones, A. H. Forman.

HAFFORD, W. B., Assistant Professor of Mechanical Engineering, Montana State College, Bozeman, Mont. F. C. Blake, R. A. Seaton.

JOERGER, C. ALBERT, Professor of Mechanical Engineering, University of Cincinnati, Cincinnati, Ohio. C. W. Park, H. B. Luther.

JOHNSON, J. RICHARD, Professor of Applied Mechanics, University of Kentucky, Lexington, Ky. W. E. Freeman, E. A. Bureau.

KRAUSS, J. E., Personnel Representative, E. I. duPont de Nemours & Company, Wilmington, Del. R. L. Sackett, W. T. Magruder.

LAMKIN, ROBERT L., Industrial Relations Department, Union Carbide Company, 30 East 42nd Street, New York City. W. R. Cornell, H. S. Rogers.

LOCKWOOD, H. J., Professor of Power Engineering, Dartmouth College, Hanover, N. H. R. R. Marsden, H. P. Hammond.

MCCORMICK, ROBERT L., Professor of Civil and Architectural Engineering, Rose Polytechnic Institute, Terre Haute, Ind. C. L. Mees, F. L. Bishop.

MARSH, MALCOLM R., Adjunct Professor of Engineering and Mathematics, Texas College of Mines and Metallurgy, El Paso, Texas. C. V. Mann, F. L. Bishop.

MOCK, CLIFTON O., Instructor in Drawing, University of Kentucky, Lexington, Ky. L. E. Nollau, D. C. Jackson, Jr.

O'ROURKE, EDWARD V., Assistant Professor of Mine Engineering, The Ohio State University, Columbus, Ohio. E. A. Hitchcock, H. E. Nold.

RICKLY, OSCAR D., Assistant Professor of Industrial Engineering, The Ohio State University, Columbus, Ohio. W. A. Knight, P. W. Ott.

SNOW, FRANKLIN C., Professor of Civil Engineering, Georgia School of Technology, Atlanta, Ga. W. V. Dunkin, R. S. King.

SQUIRE, EDWARD J., Professor of Structural Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. E. J. Streubel, H. P. Hammond.

THURLOW, ALEXANDER W., Instructor in Mechanical Engineering, Northeastern University, Boston, Mass. F. A. Stearns, J. Meller.

Respectfully submitted,

F. L. BISHOP, Secretary.

MINUTES OF THE THIRTY-SEVENTH ANNUAL MEETING OF THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION, THE OHIO STATE UNIVERSITY, COLUMBUS, OHIO, JUNE 19–22, 1929

The thirty-seventh annual meeting of the Society for the Promotion of Engineering Education was held at The Ohio State University, Columbus, Ohio, June 19 to 22, 1929. The meetings were held in Room 100, Chemistry Building. The President of the Society, Dexter S. Kimball, presided. There were 548 members and guests registered. The keynote of the meeting was "The Graduate and His Work."

Two conferences were held on Wednesday morning. The conference on Drawing was held in Room 203, Brown Hall, with the Chairman of the Division on Drawing, Thos. E. French, presiding. The conference on Industrial Engineering was held in Room 200, Industrial Engineering Building, with the Chairman of the Committee on Industrial Engineering, C. W. Lytle, presiding. Reports of these conferences will be published in the JOURNAL OF ENGINEERING EDUCATION.

WEDNESDAY, JUNE 19, 1929

The opening session of the thirty-seventh annual meeting was held in Room 100, Chemistry Building, and was called to order at two o'clock by the President of the Society, Dexter S. Kimball, who is Dean of the College of Engineering, Cornell University, Ithaca, N. Y. President Kimball introduced George W. Rightmire, President of The Ohio State University, who welcomed the members and guests to the University. President Kimball responded for the Society.

The topic for the opening session was "The Graduate and his Work." Mr. R. I. Rees, Assistant Vice-President of the American T. & T. Company, and Mr. C. R. Dooley, Manager of Personnel and Training, Standard Oil Company of New

York, presented this subject from the standpoint of industry. Dean H. S. Evans, University of Colorado, Director P. M. Lincoln, Cornell University, Dean Louis Mitchell, Syracuse University, and Professor Wm. T. Magruder, Ohio State University, represented the educational institutions.

These presentations were discussed by W. H. Timbie, Massachusetts Institute of Technology; Carl S. Coler, Westinghouse E. & M. Company; Cyril M. Jansky, University of Wisconsin; George B. Thomas, Bell Telephone Laboratories; Harry P. Hammond, Brooklyn Polytechnic Institute; Charles F. Scott, Yale University, and P. M. Lincoln, Cornell University.

THURSDAY, JUNE 20, 1929

At 8:30 A.M., the following conferences were held:

Civil Engineering, Room 109, Brown Hall, A. H. Fuller, Iowa State College, presiding. The subject of this conference was "Coordination of the Civil Engineering Curriculum and the Work of the Civil Engineer after Graduation." The discussion was lead by John M. Fitzgerald, Committee on Public Relations of Eastern Railroads, Frank H. Sheets, Illinois Division of Highways, and Philip Burgess, Contracting Engineer.

Drawing, Room 203, Brown Hall, Thos. E. French, The Ohio State University, presiding.

Electrical Engineering, Room 272, Robinson Laboratory, Paul Cloke, University of Maine, presiding. The topic of this conference was "The Relation of the Undergraduate Curriculum in Electrical Engineering to Work after Graduation" Papers were presented as follows:

"The Place of Illumination and Photometry in the Electrical Engineering Curriculum," by H. H. Higbie, University of Michigan;

"Lecture-Room Demonstration of Certain Phenomena in Communication Engineering," by H. L. Everitt, Ohio State University;

"The Engineering Educational Program of California Institute of Technology," by R. W. Sorensen of that institution;

"Electrical Measurement in Determining the Elastic Resistance and Endurance of Metals," by C. A. P. Turner, Minneapolis.

Engineering Problems and Orientation, Room 108-A, Chemistry Building, F. C. Dana, Iowa State College, presiding. The topic of discussion was "Organization and Administration of Engineering Problems Courses."

English, Room 120, Chemistry Building, Sada A. Harbarger, Ohio State University, presiding. "What Should the Courses in English Contribute to the Preparation of the Graduate?" was discussed by C. S. Coler, Westinghouse E. & M. Co.; H. L. Creek, Purdue University; Alfred D. Flinn, The Engineering Foundation; T. M. Focke, Case School of Applied Science; H. W. Richardson, *Engineering News-Record*, and J. M. Weed, Ohio State University.

The second session was held at 11 A.M., in Room 100, Chemistry Building, with Vice-President C. C. Williams, University of Iowa, in the chair. This session was devoted exclusively to the Presidential Address: "The Economic and Social Significance of Engineering" by Dexter S. Kimball, President of the Society, and Dean, College of Engineering, Cornell University.

It was the unanimous opinion of the members that this address should be given as wide publicity as possible within the means of the Society and they instructed the officers to do so.

At the close of this session a photograph of all the members and guests attending the convention was taken.

At 2 P.M., there was a meeting of the Institutional Division in Room 100, Chemistry Building, with C. C. Williams, Chairman of the Division, presiding.

The first item of business taken up was a motion "That a committee of the Institutional Division be appointed to study and report on the propriety of extending the institutional membership of the Society to non-collegiate institutions." Motion carried.

Three committee reports were then presented—Committee on Coordination of Preparatory and Engineering Education, T. M. Focke, Chairman, Case School of Applied Science; Committee on Industrial Aptitudes of Technical Graduates, Arthur M. Greene, Jr., Chairman, Princeton University; Committee on Personnel Instruction, R. L. Sackett, Chairman, Pennsylvania State College.

Mr. Sam A. Lewisohn, Vice-President of the Miami Copper Company, addressed the Division on "The Technique of Labor Administration."

At four o'clock there was a conference on **Student Sections** held in Room 100, Chemistry Building, with Dean A. A. Potter, Purdue University, presiding.

"Basis for Recognition of Colleges by the National Engineering Societies" was discussed by Wm. T. Magruder, A. S. M. E.; J. L. Beaver, A. I. E. E.; Edward Bartow, A. I. Ch. E.; H. P. Hammond, A. S. C. E.; and E. A. Holbrook, A. I. M. & M. E.

"What Specific Contributions can the National Engineering Societies Make Through the Student Branches?" was discussed by C. M. Jansky, A. I. E. E.; W. K. Hatt, A. S. C. E.; R. A. Seaton, A. S. M. E.; D. J. Demorest, A. I. M. & M. E.; and John Younger, A. S. I. E., S. A. E.

The annual dinner was held at the Elks' Home and President Kimball presided.

The second Lamme gold medal was given to Irving Porter Church, Professor Emeritus of Mechanics and Hydraulics at Cornell University. Professor Church was not present, due to illness, and Director P. M. Lincoln received it for him. The Committee to select the recipient for this award was C. S. Coler, Chairman, B. F. Bailey, H. V. Carpenter, O. W. Eshbach, W. B. Gregory, H. H. Jordan, R. S. King, A. E. Morgan, G. H. Pfeif, E. W. Rettger, C. B. Stanton, and C. C. Williams.

Brigadier General W. E. Gilmore, Chief of the Material Division of the Air Corps of the United States Army, Dayton,

Ohio, addressed the members on "Aircraft Development." This address was illustrated by moving pictures.

FRIDAY, JUNE 21, 1929

The third session was held in Room 100, Chemistry Building and President Kimball called the meeting to order at nine o'clock.

The members stood silent for a moment in memory of Alfred Dodge Cole, Frank Mason Comstock, C. I. Corp, William Esty, Peter Gillespie, W. F. M. Goss, J. Lawrence Hagy, Robert M. Raymond, Frank Caspar Wagner, Arthur Silas Wright, Charles Allen Wright, who have passed away during the year.

In the absence of D. C. Jackson, Chairman of the Nominating Committee, Secretary Bishop read the report:

For President, R. I. Rees, Assistant Vice-President, American Telephone and Telegraph Company, New York City.

For Vice-Presidents, E. A. Hitchcock, Dean, College of Engineering, The Ohio State University, Columbus, Ohio, and Edward Bennett, Professor of Electrical Engineering, University of Wisconsin.

For Treasurer, W. O. Wiley, President, John Wiley & Sons, Inc., New York City.

For Secretary, F. L. Bishop, Professor of Physics, University of Pittsburgh.

For Members of the Council to serve three years:

I. C. Crawford, University of Idaho,
C. R. Dooley, Standard Oil Company of New York,
R. C. H. Heck, Rutgers University,
H. H. Higbie, University of Michigan,
W. C. Huntington, University of Illinois,
N. C. Riggs, Carnegie Institute of Technology,
W. H. Timbie, Massachusetts Institute of Technology.

Upon motion the nominations were closed and the Secretary cast the unanimous ballot of the Society for the nominees.

Past-President Greene escorted President-Elect Rees to the rostrum amid prolonged applause. Mr. Rees said: "I stand before you in great humility. I am overwhelmed by the com-

pliment you have paid me and the deep obligation which you have imposed upon me.

"It would seem, from the character of the programs of this Society during the past two or three years, that there is an increasing appreciation of the common problems and the common responsibilities in connection with the development of the young men of our country and there is a closer tie between education, particularly engineering education, and industry and business.

"During the past year of the investigation, I have worked with committees and have contributed a minute share to some of the problems. One of the things which impresses me more than anything else is the fact that there is nobody more capable of doing the investigation than the members of this Society themselves.

"It has been an inspiration and a stimulus to me, and to all of us in industry, to realize the willingness on the part of every individual in the Society to take on his full share of work.

"As I say, I take this obligation with all humility, but with the confidence that, with the counsel and advice of the Council of this Society, of its past presidents, and of each individual member, combining in its total the leadership in engineering education, I shall at the conclusion of this year, with your assistance, show a steady progress made by the Society such as it has made in the past years. I hope the progress will be continued and I shall feel honored to the highest degree if I may be able to contribute one little bit toward that future progress."

When Vice-President-Elect Bennett was introduced, he said: "I am very deeply appreciative of the honor that has been conferred upon me. I have the feeling that the work in which the Society is engaged is of the most fundamental importance and it will be a great privilege to do what I can to uphold the right—or the left—hand of General Rees during the coming year."

Vice-President-Elect Hitchcock made his bow and said: "While I do not want to cast any reflections upon the judg-

ment of our Nominating Committee, I do want to say this: They were wise enough not to say anything to me before announcing it. Nevertheless, I believe in compulsory military drills."

Charles F. Scott, Chairman of the Board of Investigation and Coordination, presented the report of that Board.

Director W. E. Wickenden presented the report of his work. President Kimball paid tribute to the work which Mr. Wickenden has done and the Society gave him a rising vote of thanks and wished him Godspeed in his new duties as President of the Case School of Applied Science which he assumes September 1, 1929.

Mr. H. P. Hammond, Director of Summer Schools for Engineering Teachers for the Society, reported on his activities.

Mr. Robert H. Spahr presented a report on the investigation of non-collegiate technical institutes which the Society has been conducting for the past year.

President Kimball, in asking Past-President Scott to escort his father to the front of the room so that we might pay our respects to him, said: "We who live in these later days when education is taken for granted should miss no opportunity to honor those who bore the heat and the burden of the days of the pioneers' times and made possible modern education and such organizations as ours. We have such a man with us this morning, William Henry Scott, former President of The Ohio State University, and father of Charles Felton Scott." The members arose and applauded Mr. Scott.

Mr. L. W. Wallace, Secretary of the American Engineering Council, described the organization and functioning of the Council.

Dean E. A. Hitchcock of The Ohio State University presented his paper on "Some Reflections on Engineering Education."

The fourth session of the thirty-seventh annual meeting was held in Room 100, Chemistry Building, at 2:00 P.M., with President Kimball in the chair.

President A. E. Morgan of Antioch College read his paper

on "The Mississippi River Flood Control." Professor W. L. Evans, The Ohio State University, gave a vivid description of "Teaching of Chemistry to Freshmen." Alexander Klemin of New York University, not being able to attend the meeting due to being called to active service at Langley Field, his paper was read by title—"Present Status of Aeronautical Engineering Education."

The following reports were read:

Sections and Branches, H. S. Evans,
Civil Engineering, A. H. Fuller,
English, Sada A. Harbarger;
Orientation and Engineering Problems, F. C. Dana;
Mechanics, A. P. Poorman;
Relations of Engineering Colleges to Railroads, S. W. Dudley.

The Society formally adopted the report of the Committee on Resolutions. The report reads:

WHEREAS, The thirty-seventh annual meeting of the Society for the Promotion of Engineering Education has been held under the auspices of The Ohio State University,

Therefore, be it resolved that the officers and members of the Society extend their cordial and very hearty thanks to

President George W. Rightmire,

Dean E. A. Hitchcock,

Professor Wm. T. Magruder, Chairman of the General Committee,

Mrs. E. A. Hitchcock, Chairman of the Ladies Entertainment Committee, and to all other members of the various committees and of the faculty who have provided such excellent facilities and such gracious and hospitable entertainment for the members, their families, and guests;

To the members of the various social and commercial organizations of the city of Columbus who have also done so much for our comfort and pleasure;

To Dr. Philips Thomas of the Westinghouse Electric and Manufacturing Company, and to Brig. Gen. W. E. Gilmore, U. S. Army Air Corps, for their very interesting and instructive lectures, and

To the several industrial and engineering organizations which have afforded our members opportunities of visiting their plants;

To the McGraw-Hill Book Company for the registration list which they so kindly had printed.

All of these factors have contributed to make this, the thirty-seventh annual meeting, one of the pleasantest and most successful in the history of the Society.

(Signed) D. S. ANDERSON,
R. A. SEATON,
S. B. EARLE, *Chairman.*

The meeting adjourned at four o'clock to meet at the Ecole Polytechnique and McGill University in June, 1930.

(Signed) F. L. BISHOP, *Secretary.*

OFFICERS 1929–30

President

R. I. Rees, 195 Broadway, New York City.

Vice-Presidents

E. A. Hitchcock, The Ohio State University, Columbus, Ohio.
Edward Bennett, University of Wisconsin, Madison, Wis.

Secretary

F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.

Treasurer

W. O. Wiley, 440 Fourth Avenue, New York City.

Assistant Secretary

Nell McKenry, University of Pittsburgh, Pittsburgh, Pa.

COUNCIL

I. Elective Members

Terms Expire in 1930

J. M. BRYANT, University of Minnesota, Minneapolis, Minn.
S. B. EARLE, Clemson College, Clemson College, S. C.
S. S. EDMANDS, Pratt Institute, Brooklyn, N. Y.
H. P. HAMMOND, Brooklyn Polytechnic Institute, Brooklyn, N. Y.
A. C. LANIER, University of Missouri, Columbia, Mo.
C. M. MCKERGOW, McGill University, Montreal, Canada.
D. B. PRENTICE, Lafayette College, Easton, Pa.

Terms Expire in 1931

PAUL CLOKE, University of Maine, Orono, Me.
C. S. COLER, Westinghouse E. & M. Co., East Pittsburgh, Pa.
R. C. DISQUE, Drexel Institute, Philadelphia, Pa.
T. M. FOCKE, Case School of Applied Science, Cleveland, Ohio.
H. S. ROGERS, Oregon Agricultural College, Corvallis, Ore.
C. H. WARREN, Yale University, New Haven, Conn.
J. J. WILMORE, Alabama Polytechnic Institute, Auburn, Ala.

Terms Expire in 1932

I. C. CRAWFORD, University of Idaho, Moscow, Ida.
C. R. DOOLEY, 26 Broadway, New York City.
R. C. H. HECK, Rutgers University, New Brunswick, N. J.
H. H. HIGBIE, University of Michigan, Ann Arbor, Mich.
W. C. HUNTINGTON, University of Illinois, Urbana, Ill.
N. C. RIGGS, Carnegie Institute of Technology, Pittsburgh, Pa.
W. H. TIMBIE, Massachusetts Institute of Technology, Cambridge, Mass.

II. Past Presidents—Members Ex-Officio

GEORGE F. SWAIN, 1574 Beacon St., Brookline, Mass.
C. FRANK ALLEN, 88 Montview St., West Roxbury, Mass.
D. C. JACKSON, Massachusetts Institute of Technology, Cambridge, Mass.
CHAS. S. HOWE, Case School of Applied Science, Cleveland, Ohio.
F. E. TURNEAURE, University of Wisconsin, Madison, Wis.
H. S. MUNROE, Litchfield, Conn.
A. N. TALBOT, University of Illinois, Urbana, Ill.
W. T. MAGRUDER, Ohio State University, Columbus, Ohio.
G. C. ANTHONY, 5457 Page Blvd., St. Louis, Mo.

ANSON MARSTON, Iowa State College, Ames, Iowa.
HENRY S. JACOBY, 650 Highland Avenue, Bethlehem, Pa.
G. R. CHATBURN, University of Nebraska, Lincoln, Nebr.
MILO S. KETCHUM, University of Illinois, Urbana, Ill.
ARTHUR M. GREENE, JR., Princeton University, Princeton, N. J.
MORTIMER E. COOLEY, Paulon, Ga.
CHAS. F. SCOTT, Yale University, New Haven, Conn.
A. A. POTTER, Purdue University, Lafayette, Ind.
G. B. PEGRAM, Columbia University, New York City.
O. M. LELAND, University of Minnesota, Minneapolis, Minn.
R. L. SACKETT, Pennsylvania State College, State College, Pa.
D. S. KIMBALL, Cornell University, Ithaca, N. Y.

BOARD OF INVESTIGATION AND COORDINATION

D. C. JACKSON, Professor of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass.
D. S. KIMBALL, Dean, College of Engineering, Cornell University, Ithaca, N. Y.
R. L. SACKETT, Dean, School of Engineering, Pennsylvania State College, State College, Pa.
F. E. TURNEAURE, Dean, College of Engineering, University of Wisconsin, Madison, Wis.
CHAS. F. SCOTT, Chairman, Professor of Electrical Engineering, Sheffield Scientific School, Yale University, New Haven, Conn.
F. L. BISHOP, Secretary, Professor of Physics, University of Pittsburgh, Pittsburgh, Pa.
R. I. REES, Assistant Vice-President, American T. & T. Co., 195 Broadway, New York City, *President of the Society 1929–30.*

W. E. WICKENDEN, Director of Investigations. (Resigned September 1, 1929.)
H. P. HAMMOND, Director of Summer Schools for Engineering Teachers, Brooklyn Polytechnic Institute, Brooklyn, N. Y.
R. H. SPAHR, Member of Staff. (Resigned September 1, 1929.)

COMMITTEES FOR 1929–30

In order that the work of the Society may be continuous and progressive a large part of it is conducted by committees under the direction of the Committee on Committees.

Members having matters they desire to take up with any chairman are invited to correspond with him directly.

Executive Committee: R. I. Rees, *Chairman*, 195 Broadway, New York, N. Y.; F. L. Bishop and W. O. Wiley.

Publication Committee: F. L. Bishop, *Chairman*, University of Pittsburgh, Pittsburgh, Pa.; D. S. Kimball and R. I. Rees.

Program Committee: R. I. Rees, *Chairman*, 195 Broadway, New York, N. Y.; E. A. Hitchcock, Edward Bennett, F. L. Bishop and W. O. Wiley.

Committee on Committees: R I. Rees, *Chairman*, E. A. Hitchcock, Edward Bennett, F. L. Bishop and W. O. Wiley.

Agricultural Engineering: J. B. Davidson, *Chairman*, Iowa State College, Ames, Iowa; Wm. Boss, Daniel Scoates, H. B. Walker and R. B. West.

Civil Engineering: A. H. Fuller, *Chairman*, Iowa State College, Ames, Iowa; J. L. Newcomb, J. C. Tracy, J. R. Lapham, L. E. Conrad, F. C. Snow.

Cooperative Engineering Education: W. H. Timbie, *Chairman*, Massachusetts Institute of Technology, Cambridge, Mass.; Herman Schneider, F. E. Ayer, C. W. Lytle, D. C. Jackson, Jr., K. G Matheson, J. E. McDaniel, E. W. Whited.

Electrical Engineering: Paul Cloke, *Chairman*, University of Maine Orono, Me.; R. E. Doherty, J. W. Barker, R. W. Sorensen, H. W. Price, J. R. Benton.

Engineering Research: C. R. Richards, *Chairman*, Lehigh University, Bethlehem, Pa.; G. M. Braune, R. A. Seaton, H. H. Higbie, H. S. Sheppard, J. H. Morecroft, C. F. Harding.

English: Sada A. Harbarger, *Chairman*, Ohio State University, Columbus, Ohio; J. Raleigh Nelson, W. O. Birk, H. G. Pearson, H. C. Richardson, H. L. Creek.

Industrial Engineering: E. B. Norris, *Chairman*, Virginia Polytechnic Institute, Blacksburg, Va.; H. B. Hastings, D. B. Porter, J. O. Keller, John Younger.

Lamme Award: C. S. Coler, *Chairman*, Westinghouse E. & M. Co., East Pittsburgh, Pa.; Appointed for four years: W. C. Huntington, University of Illinois, C. L. Kinsloe, Pennsylvania State College, A. V. Millar, University of Winconsin; Three years:

C. C. Williams, University of Iowa, W. B. Gregory, Tulane University, A. E. Morgan, Antioch College; Two years: C. S. Coler, W. E. & M. Co., O. W. Eshbach, American T. & T. Co., G. H. Pfeif, General Electric Co.; One year: H. V. Carpenter, State College of Washington, E. W. Rettger, Cornell University, R. S. King, Georgia School of Technology.

Mathematics: E. R. Hedrick, *Chairman*, University of California at Los Angeles; H. W. March, J. H. Weaver, T. C. Fry, W. J. Berry, H. L. Rietz, L. O'Shaughnessy.

Mechanical Engineering: C. H. Berry, *Chairman*, Harvard University, Cambridge, Mass.; G. W. Munro, F. W. Marquis, A. J. Wood, J. J. Wilmore, G. A. Pennock, Albert Sobey.

Mining and Metallurgy: W. O. Hotchkiss, *Chairman*, Michigan College of Mines and Technology, Houghton, Mich.; R. M. Black, R. S. McCaffery, W. G. McBride, C. M. Young, Jos. Daniels, H. E. Nold.

Orientation and Engineering Problem Courses: F. C. Dana, *Chairman*, Iowa State College, Ames, Iowa; J. J. Richey, E. R. Wilcox, E. H. Wright, D. G. Paterson, W. A. Knapp.

Relation of Engineering Colleges with Railroads. S. W. Dudley, *Chairman*, M. S. Ketchum, Anson Marston, C. H. Mitchell, A. A. Potter, H. E. Riggs, G. F. Swain, F. E. Turneaure.

Sections and Branches: Edward Bennett, *Chairman*, University of Wisconsin, Madison, Wis.; H. S. Evans, T. J. Hoover, C. M. McKergow, J. M. Foster, Paul Cloke, H. C. Sadler.

Standardization of Technical Nomenclature: J. T. Faig, *Chairman*, Ohio Mechanics Institute, Cincinnati, Ohio; R. L. Daugherty, J. E. Emswiler, Sanford A. Moss.

DIVISIONS OF THE SOCIETY

Engineering Drawing

Executive Committee: T. E. French, *Chairman*, The Ohio State University, Columbus, Ohio; R. P. Hoelscher, F. G. Higbee, H. H. Jordan, H. M. McCully, C. V. Mann, W. G. Smith.

Institutional

Executive Committee: E. A. Hitchcock, *Chairman*, The Ohio State University, Columbus, Ohio; C. C. Williams, I. C. Crawford, S. B. Earle, Geo. W. Case, H. M. MacKay.

Instruction on Industrial Relations: R. L. Sackett, *Chairman*, The Pennsylvania State College, State College, Pa.; D. A. Kimball, J. W. Roe, J. E. Walters, J. W. Hallock, F. E. Ayer.

Coordination of Preparatory and Engineering Education: T. M. Focke, *Chairman*, Case School of Applied Science, Cleveland, Ohio; O. M. Leland, H. H. Jordan, H. W. Miller, B. M. Brigman, A. L. Colston.

Graduating Personnel: A. M. Greene, Jr., *Chairman*, Princeton University, Princeton, N. J.; D. S. Kimball, E. A. Hitchcock, R. I. Rees, J. P. Jackson, R. E. Doherty, E. B. Roberts.

Mechanics

Executive Committee: A. P. Poorman, *Chairman*, Purdue University, Lafayette, Ind.; G. P. Boomsliter, J. E. Boyd, E. W. Rettger, C. E. Paul, E. R. Maurer, S. M. Woodward, N. C. Riggs, LeRoy Tucker.

Physics

Executive Committee: W. N. St. Peter, *Chairman*, University of Pittsburgh, Pittsburgh, Pa.; O. M. Stewart, W. R. Wright, W. L. Severinghaus, Albert Ball, C. G. Watson, G. M. Wilcox.

PROCEEDINGS OF THE SOCIETY

"The JOURNAL shall contain the proceedings of the annual convention, and such other pertinent papers as may be submitted to, and approved by, the Publication Committee. A bound volume of the JOURNAL for each current year shall constitute the PROCEEDINGS of the Society."

"Volumes of the PROCEEDINGS will be sold to members who subscribe for them at a cost to be determined each year by the Executive Committee. Subscriptions for the PROCEEDINGS must be received in advance by the Secretary."

The above are quotations from the Constitution of the Society. The price of Volume XXXVII, PROCEEDINGS, is $2.00 per copy.

It is necessary to receive subscriptions in advance in order that we might have sufficient copies printed when the first issue in September is published. The printer runs off these extra copies each month and at the end of the year binds them together, after they are indexed, and mails them to those persons who have subscribed for them.

In order that those members who did not realize that Volume XXXVII of the PROCEEDINGS must be ordered in advance, we shall hold the type of the September JOURNAL until October 10, after which time it will be torn down. The PROCEEDINGS may be paid for at the time of subscribing or upon receipt of the volume. Please send your subscription NOW to the Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa. Price, $2.00.

NEW DIVISION

The Council has approved the petition for the formation of a division of the Society to be known as the "Division on Mechanics."

NEW MEMBERS

BRIDGE, LAWRENCE R., Instructor in Mechanical Engineering, University of Pittsburgh, Pittsburgh, Pa. Nell McKenry, F. L. Bishop.

COLBY, WHITNEY C., Training Assistant, Standard Oil Company of N. J., 26 Broadway, New York City. C. R. Dooley, H. L. Davis.

CONLEY, WILLLIAM J., Junior Professor of Applied Mechanics, University of Rochester, Rochester, N. Y. A. P. Poorman, E. W. Rettger.

EDWARDS, WM. WESLEY, Head, Steam Engineering Department, Wentworth Institute, Boston, Mass. G. W. Munro, H. P. Hammond.

ELLENWOOD, FRANK O., Professor of Power Engineering, Cornell University, Ithaca, N. Y. H. P Hammond, C. Harold Berry.

FERNOW, BERNHARD E., Professor of Mechanical Engineering, Clemson Agricultural College, Clemson College, S. C. H. P. Hammond, H. F. Roemmele.

GRAW–HENRY, CARLINE, Instructor in Machine Design, Rose Polytechnic Institute, Terre Haute, Ind. A. A. Potter, H. P. Hammond.

JURDAK, MANSUR, Professor of Mathematics, Director, Engineering Classes, American University of Beirut, Beirut, Syria. F. L. Bishop, Nell McKenry.

KAPP, CECIL A., Director, Cooperative Education, Drexel Institute, Philadelphia, Pa.; J. E. McDaniel, Chas. W. Lytle.

LARSON, C. WILLIAM, Instructor in Mechanical Engineering, Worcester Polytechnic Institute, Worcester, Mass. Alfred J. Ferretti, H. P. Hammond.

MANSFIELD, EDWARD S., Head, Educational Bureau, The Edison Electric Illuminating Company of Boston, 39 Boylston Street, Boston, Mass. Karl L. Wildes, Dugald C. Jackson.

MERRICK, CHARLES M., Instructor in Mechanical Engineering Lafayette College, Easton, Pa. H. P. Hammond, A. A. Potter.

MESSERSMITH, CHARLES W., Instructor in Mechanical Engineering, Purdue University, Lafayette, Ind. H. L. Solberg, H. P. Hammond.

PEDDLE, JOHN B., Professor of Machine Design, Rose Polytechnic Institute, Terre Haute, Ind. H. P. Hammond, A. A. Potter.

PENNOCK, GEORGE A., Assistant Works Manager, Western Electric Company, Hawthorne Station, Chicago, Ill. R. I. Rees, F. L. Bishop.

REULING, WALTER E., Assistant Professor of Mechanical Engineering, Michigan State College, East Lansing, Michigan. H. P. Hammond, W. R. Halliday.

THATCHER, CHAS. G., Associate Professor of Mechanical Engineering, Swarthmore College, Swarthmore, Pa. S. W. Dudley, H. P. Hammond.

WILLARD, FREDERIC, Personnel Director, Western Electric Co., Inc., 195 Broadway, New York City. R. I. Rees, F. L. Bishop.

WISCHMEYER, CARL, Professor of Mechanical Engineering, Rose Polytechnic Institute, Terre Haute, Ind. H. P. Hammond, W. S. Ayars.

OBITUARY

Horace Wilmer Marsh

Pratt Institute suffered great and irreparable loss in the sudden death of Horace Wilmer Marsh, May 29, 1929. He was head of the Department of Mathematics and English in the School of Science and Technology for the past thirty-three years and prominent in Institute activities.

Mr. Marsh prepared for college at Keystone Academy, Factoryville, Pa., entering Lafayette College and graduating with the degrees of bachelor of arts and master of Arts in 1889. He became principal of Talladega College, Alabama, and later taught Latin and Anglo Saxon at the college of Emporia, Kansas. He was a graduate student in education and philosophy of Columbia University in 1898, having meanwhile come to Pratt Institute, and was lecturer at the University of California's summer session of 1914. Mr. Marsh was a member of Phi Beta Kappa and the Association of Mathematics Teachers of the Middle States. As an author, Mr. Marsh is widely known by his "Technical Mathematics" texts in four volumes, notable for the original methods employed, by which the student is led to learn by actual doing. For many years, as Supervisor of Entrance Examinations, his able judgment guided the selection of students for the School of Science and Technology. Mr. Marsh was an outstanding man and teacher. His character was vigorous and positive, and he was independent in thought and action. But he had a tender heart that never failed to respond sympathetically to students, alumni, and faculty associates who came to him for aid and counsel. Mr. Marsh had been a member of the Society since 1926.

Edward Robinson

Edward Robinson, head of the Department of Mechanical Engineering, University of Vermont, was struck by an automobile in front of his summer home at Thomaston, Maine, on the morning of August 9. He lived about four hours after the accident but did not gain consciousness. He is survived by his wife and one son, Edward S., who is a graduate student at Harvard.

Professor Robinson was born in Vineland, N. J., December 23, 1865. He was educated at the Thomaston, Maine, high school, the Massachusetts Institute of Technology from which he received the degree of B.S. in M.E. in 1890. After serving as laboratory assistant at the Institute one year he became assistant superintendent of the Hartford, Conn., Cycle Co. After a service of a year he returned to the institute as instructor in mechanical drawing and descriptive geometry, and remained in this position until his appointment in 1896 to the professorship of mechanical engineering in the Clarkson College of Technology, Potsdam, N. Y. In 1902 he accepted a call to the University of Vermont which he served continuously for twenty-seven years.

In the death of Professor Robinson the engineering profession loses a devoted and enthusiastic member. His interests were not restricted to the scientific and technical side of engineering but extended to its broader economic and humanitarian aspects and possibilities. To him it was one of the greatest agencies for the promotion of human welfare and the advancement of society. He was an early and zealous advocate of F. W. Taylor's idea of scientific management and one of the first to introduce a course in scientific management into the engineering curriculum. The three weeks immediately preceding his tragic death were spent at the Summer School of the Society at Purdue in which he was a most attentive and appreciative student. The experience at this school he regarded as profitable as it was enjoyable.

He was a member of the A.S.M.E., and rarely missed, if ever, an annual meeting. He took a deep interest in the activi-

ties of the American Engineering Council, of which he was a member. The work of the S.P.E.E. also made a strong appeal to him and he was a regular attendant at all meetings. He was interested in the Taylor Society. He was past-president of the Vermont Society of Engineers.

The dominant trait in Professor Robinson's character was a friendly human interest. In his department, assistants and students alike were friends. Among the students he was affectionately known as "Robbie." As a teacher he was patient, painstaking and thorough. The successful student was sure of ample recognition, and the less successful, whether from lack of talent or lack of application, was equally sure of considerate treatment. For many years he was a member of the Student Council, in whose deliberations he was deeply interested. In him the students felt that they had a wise, sympathetic and tolerant advisor.

Professor Robinson had been a member of the Society since 1899.

COLLEGE NOTES

University of Southern California.—John Franklin Dodge, fuel oil engineer of the Standard Oil Company of California and a recognized authority on gas conservation, has been named professor of petroleum engineering in the College of Engineering of the University of Southern California.

Mr. Dodge holds three degrees from California Universities; a degree of bachelor of science from the College of Mining, University of California; a master of science degree from the University of Southern California, and the degree of mining engineer from the University of California. Following his graduation from college he engaged in mining and petroleum engineering in Nevada, Arizona, and California, and taught engineering at the Polytechnic College at Los Angeles.

In 1918 he became petroleum engineer with the Southern Pacific Company, fuel oil department, and its successor, the Pacific Oil Company, which was later merged with the Standard Oil Company of California. During the past year he has been in charge of gas conservation, injection and storage for the Standard Oil Company, and the representative of his company on the operators' general gas conservation committee and the engineers' repressuring and storage committee. He was recently named as one of the three advisors to the state petroleum empire. Since 1925 he has been a lecturer on oil land valuations and other petroleum engineering subjects at Stanford University.

David M. Wilson, who has been appointed assistant professor of civil engineering, taking the place of Professor R. M. Fox, on leave of absence in England, was graduated from the University of Michigan with the degree of B.S. in C.E. in 1920. For two years he was instructor of Mathematics at the University of Michigan. Beginning in 1920 he was instructor in Mechanics and Structural Engineering at the University of Wisconsin for four years. Before graduating from the University of Michigan he spent about three years in civil engi-

neering work in the vicinity of Detroit. Following his connection with the University of Wisconsin, that is from 1924 to 1929, he was assistant engineer in charge of drainage and irrigation work, building design and construction, etc., with the Central Aguirre Sugar Company, Central Aguirre, Porto Rico.

Gilbert H. Dunstan, newly appointed instructor in civil engineering, received the degree B.S. in C.E. in 1926 and B.S. in E.E. in 1927, both from the University of Southern California. Prior to his graduation Mr. Dunstan had had a considerable variety of civil engineering work, including irrigation work, in the vicinity of Los Angeles. In 1927 he went to the Westinghouse Electric and Manufacturing Company in East Pittsburgh as student engineer, remaining there until February, 1928, when he became a graduate student in civil engineering at the University of Iowa. He is now completing the work for his M.S. in C.E. at that institution. During the year 1928–29 he has been instructor in civil engineering at Tulane University. Mr. Dunstan will have charge of the work in general engineering drawing, hydraulics, and other subjects.

Sidney F. Duncan was graduated from the California Institute of Technology in 1924 with the degree of B.S. in M.E. He returned to the same school and received the degree of B.S. in E.E. in the year 1925. Leaving the California Institute of Technology in 1925 he had two years experience in general engineering work at the General Electric Company at Schenectady and two years in engineering work with the Bailey Meter Company of Cleveland, Ohio.

SECTIONS AND BRANCHES

The New England Section of the Society for the Promotion of Engineering Education held a meeting at the Yale Engineering Camp, East Lyme, Connecticut, on May 11. Dinner was served at twelve thirty, after which the group gathered in the assembly hall.

The meeting was presided over by the chairman of the society, Dean C. H. Warren of the Sheffield Scientific School. The first speaker was Professor J. W. Barker, of the Massachusetts Institute of Technology, who spoke on "Sectioning of Classes on the Basis of Mental Speed and Honors Work in Electrical Engineering at Massachusetts Institute of Technology." The practice at the institute was explained. Following the talk there was an extended discussion and Professor Barker answered a good many questions.

The second speaker was Professor E. D. Smith, of Yale University, who discussed "The Teaching of Personnel Management." This talk also proved of great interest and brought out the particular problem used by the speaker.

The Nominating Committee, appointed by Chairman Warren and made up of Professors C. F. Scott of Yale, Chairman, and A. E. Watson of Brown, brought in the following nominations for officers for the coming year: Chairman, Dean Paul Cloke of the University of Maine; Secretary-Treasurer, Professor James A. Hall, Brown University. The report of the nominating committee was adopted.

Following an intermission, Professor E. J. Miles, of Yale University, addressed the group on "A New Method of Teaching Calculus."

After a vote of thanks to the Yale committee who arranged the program and acted as hosts, the meeting adjourned about 5:30 p.m. Some members stayed at the camp for supper and opportunity was offered for those who desired to stay over night.

There were forty-six present, including representatives from the following institutions: Brown, Connecticut Agricultural College, Maine, Massachusetts Institute of Technology, Norwich, Tufts, Worcester Polytechnic Institute, and Yale.

JAME A. HALL,
Secretary.

BOOK REVIEW

Inorganic Chemistry for Colleges. WILLIAM FOSTER, PH.D. D. Van Nostrand Co., Inc., New York, 1929. Pp. vi + 807.

This text is designed for college students who have had a course in high school chemistry. It is divided into four parts: Introductory; Non-metals; Metals; and Supplementary, Carbon compounds. The introduction starts with the fundamental concepts and laws, including a section on the modern ideas on the internal structure of crystals. This is followed immediately by radioactivity. This early introduction of radioactivity prepares for a modern treatment of the periodic classification and atomic structure. With these concepts clearly introduced in the first part of the book, the student will be enabled to use them as integral parts of his study. This is a far better arrangement than the too common method of inserting them at some haphazard point near the end of the book, where their effect on the student is that of something entirely foreign.

The parts on the non-metals and metals follow the conventional method and make use of the modern concepts in the introduction to some extent. Electrochemistry is inserted after the treatment of alkalis, alkaline earths, aluminum and other metals prepared electrolytically. This appears to the writer as a mistake, but not a serious one.

The organic chemistry usually given in an inorganic course forms a separate part of the book, making its inclusion or omission easy for the teacher.

The book is an admirable treatise, containing a wealth of material which is logically presented. The material is up to date, as is also the list of reading references at the end of each chapter.

E. V. H.